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The White Star Quay Completed, Showing the Landing Shed.

Excavation Work in Progress.

NEW DOCKS AT SOUTHAMPTON FOR THE GIANT OCEAN LINERS.

The Huge New Dock at Southampton

How the Docks Expand to Keep Pace with the Growth of the Steamers

By the English Correspondent of the Scientific American

The advent of the new White Star liners, and the pending new German liners which are to exceed the "Olympic" in dimensions and which are to make Southampton a port of call, has resulted in great activity and enterprise at the British port named to provide docking accommodation for these leviathans. When the White Star vessels were projected the London and South Western Railway, which owns the Southampton Docks, at once took steps to complete a huge deep water dock as Southampton is the terminal point of this steamship company. Every effort was made to complete the work in time for the arrival of the "Olympic," but it was realized as a hopeless task, in view of the dock's dimensions, so the existing Trafalgar Dock was enlarged for the purpose. Owing to the energy with which the new basin has been pushed forward it will be available in the near future. The dock itself is a parallelogram with a length of 1,700 feet by 400 feet wide. The water depth at low water spring tides is 40 feet and at high tides 53 feet. There is no entrance lock, but the largest vessels afloat or contemplated for the near future, will be able to lie in this basin at any state of the tide without danger of touching bottom. Five vessels can be held in the dock. Two vessels of the largest dimensions can berth on either side, while a short vessel can lie alongside the small end berth.

The dock is surrounded with quay walls constructed entirely of Portland cement concrete, and four large steel freight sheds are to be provided, the first for the "Olympic" berth being completed. The shed is 640 feet long by 120 feet wide, and has an annex 60 x 60 feet for baggage and dock gear. Accommodation for passengers is also provided. There is a balcony along the front side on which passengers land from the vessel, communicating with the floor of the building by two wide staircases. The train receives passengers and freight on the opposite or land side, the customs' examination being carried out on benches near this side within easy reach of the train. The communication between the vessels decks and the landing balcony will be effected by means of movable bridges. The quay is being equipped with the latest type of appliances for the expeditious handling of freight and baggage and when completed it will be one of the best equipped and most up-to-date docks in the world.

The construction of the dock, which has occupied about 3½ years, has been carried out by the engineering firm of Topham Jones & Railton, Limited, under the supervision of Mr. F. E. Wentworth Shields, the resident engineer, to whom we are indebted for these details and the accompanying illustrations. Before the work was commenced the site comprised for the most part bare mudland facing the River Test. A chalk bank separated the waterway from this flat, but as this was not completely watertight the whole area was flooded daily at high tide. The first task was to make this barrier absolutely watertight by means of a sheeting of timber piles along the toe of the bank, and covering the slope with stone pitching grouted with cement.

Excavation to a depth of 30 feet below quay level was then carried forward by means of steam shovels, which removed about 5,000 cubic yards of spoil per day. Any water which found its way through the bank by soakage was led to a special sump whence it was ejected by electrically operated centrifugal pumps. The spoil removed was for the most part taken out to sea and dumped, but a certain quantity was used for raising the mud flats in the vicinity.

To facilitate the removal of the spoil to the barges a large stage 350 feet long by 40 feet high was built out over the River Test. This stage formed the summit of a long incline which led from the heart of the dock where the steam shovels filled the ballast cars. The latter when laden were drawn up the incline by a rope railway and there tipped, the contents falling into the steam hoppers lying alongside the stage. All this excavated material had to be carried to the far end of the Isle of Wight, a distance of 25 miles, before a dumping ground could be found which was deep enough not to be choked by the dredgings.

When the steam shovels had excavated the earth to the depth of 30 feet, timbered trenches were sunk in which the foundations of the quay walls were laid. These trenches were about 43 feet wide by 45 feet deep, the bottom being about 75 feet below the quay level. Massive concrete walls of Portland cement, mixed by special machinery, were built in these trenches, and the mixing machine used for this portion of the work had a capacity of 1,000 cubic yards per day. Considerable difficulties were encountered in making these trenches as underground water found its way into the excavations and various expedients had to be resorted to in order to overcome these floodings. When the walls had reached the quay level dry material was used for filling the internal space and on this area the dock accommodation and facilities were built.

A portion of the wall at the outer end of the dock, and one of the outside quays, were not built by open excavation, but timber trenches were sunk from the quay level. The trenches in these cases were 45 feet wide by 75 deep in places, and were fine examples of heavy timbering. When the walls had been raised in this manner the inclosing bank at the entrance of the dock was cut through, permitting the water to enter, the excavation of the remaining portion of the floor of the dock being completed by bucket ladder dredgers. The excavation of the channel and turning basin outside the dock was carried out simultaneously. Four large dredgers were pressed into service for this work with a fleet of 13 hoppers and attendant craft for carrying the spoil to sea. By this means the dock floor was lowered to 40 feet below low water.

Two of the outer walls and part of the western entrance wall were built in a different manner. Here no attempt was made to dry the site, the whole wall being built in water. First the earth was removed to dredging level throughout the whole length of the wall by means of a bucket ladder dredger. Below this level the foundations were built in a trench between two rows of sheet piling driven along the front and back of the wall. The clay between the two rows of sheeting was excavated by steam grabs, and the trench was cleaned up by helmet divers. On the foundation thus obtained mass concrete was laid, being lowered through the water in special tipping boxes. Above dredging level the wall consists of large 8-ton concrete blocks at face and back with a hearting of mass concrete. This class of work is continued to a point above water level above which the wall is built entirely of mass concrete laid between shutters in the usual manner. When the wall reached quay level it was backed up with ashes of selected material.

In addition to the dock itself there are four outside quay walls varying in length from 330 to 610 feet and with depths of water at low tide of 25 to 32 feet.

Although at the time of writing the dock was not completed, the following quantities had been handled—Open excavation 873,000 cubic yards, trench excavation 318,000 cubic yards, dredging 807,000 cubic yards, representing a total volume of 1,998,000 cubic yards of spoil removed. For the constructional work 272,000 cubic yards of concrete had been laid and 42,000 tons of Portland cement used. The number of men employed on the task has been between 800 and 1,200, the whole time the work has been in progress. The plant required for the work has also been very comprehensive and modern, comprising 85 locomotives, steam shovels, cranes, pumps, pile-drivers, winding engines, air compressors, etc. A staff of 20 helmet divers was retained for setting the concrete blocks and other submarine work, and no effort has been spared to push the works on to a rapid and successful completion.

In order to provide for the dry-docking of the "Olympic" the Trafalgar graving dock had to be enlarged somewhat. When opened in 1905 this dock was more than large enough to take the largest vessel afloat at that time, the dimensions being: length over all 875 feet, width at entrance 90 feet, width inside at cope 125 feet, internal width at lowest altar 90 feet, depth over sill at high water ordinary spring tides 33 feet, and depth over blocks under the same tidal conditions 33½ feet. When the "Olympic" was placed in hand the London & South-Western Railway company decided to build a new graving dock more than large enough to hold her, but as it was realized that the task, even if pushed forward at tip-top speed would occupy at least five years, the enlargement of the existing dock was undertaken as the more expeditious solution of the problem. By the alteration the dock is now lengthened by 22 feet, widened by 10 feet, the inside width at lowest altar is increased by 12 feet, that at cope level remaining the same, while the depth over the sill is increased by 2 feet. This offers a graphic illustration of the rapid growth in the dimensions of trans-Atlantic liners.

The widening has been effected by cutting away the faces of both walls and setting back the altars. To compensate for the weight thus lost counterfort walls are being built at the back of the existing walls. The entrance gates are also being removed to be replaced by a sliding caisson. Hitherto it has been customary to dock ships at high tide only, and owing to the long period of high water it has been possible

Divers at Work Setting Masonry Blocks.

The Construction of the Quay Walls in Progress.

NEW DOCKS AT SOUTHAMPTON FOR THE GIANT OCEAN LINERS

always to complete the operation before the tide fell away. Consequently the dock gates have sufficed only for shutting water out from the dock. The new caisson, however, will be double faced and capable of holding up the water within the dock while the tide is falling, in case any extraordinary delay to the docking operations should render this necessary. The present dock pumps are arranged only for emptying the dock, so a new one is being provided for the purpose of filling it. By this means it will be possible to maintain or increase the water-depth within the dock, even when the tide is falling outside.

Southampton is a unique port inasmuch as it is served with four high tides daily. The first tide rolling up the Solent is followed two hours later by that coming up the eastern channel dividing the Isle of Wight from the mainland. The London & South Western Railway have taken full advantage of this phenomenon, and have displayed considerable enterprise in meeting developments in steamship evolution since they acquired the property some years ago.

Extended Utilization of Soya Bean Products

Milk, Cheese, and a Variety of Other Products from a Vegetable Seed

The Soya Bean, of whose growth and properties the SCIENTIFIC AMERICAN recently gave some account, is attracting increased attention abroad because of the economic and commercial value of the products obtainable from it. Some of these preparations are important because of their alimentary value, and others from their industrial applications.

Many Europeans have been studying the best method of extracting the nutritive principle contained in these seeds and preserving it in concentrated form, with a view to its availability as part of the rations of armies and particularly of colonial troops.

A Japanese chemist, Karajama, has succeeded in preparing a concentrated "milk," a flour on the order of the Nestlé preparation, and biscuits which give a maximum of alimentation with a minimum of volume.

A Chinese factory has been established not far from Paris for the purpose of manufacturing alimentary products from Soya, and it has already put upon the market Soya flour, Soya bread, Soya sauce, Soya milk, Soya cheese, preserves, fermented milk, etc.

The Indo-Chinese prepares from this plant, a condensed milk, a flour, and a form of casein which constitute essential elements of the food-supply of the populace.

Recently, moreover, successful experiments have been made, with this vegetable casein as a substitute for animal casein in the various industrial applications, in which the latter has been increasingly utilized.

The well-known chemical engineer, F. J. G. Beltzer, who has made a careful study of the whole subject, publishes in the *Revue Scientifique* a report of whose most important features we present an abstract, while omitting purely technical details of analysis and manufacture.

In the preparation of industrial casein, the imported casein made in Indo-China by the natives can be used by subjecting it to a process to remove the fatty matter contained, but it is found commercially advisable, because cheaper, to treat the raw product directly.

A quantitative analysis of 100 grams of the raw grain gave the following result:

	Grains.
Dry casein	25.55
Oils and fatty bodies	16.42
Dry residuary cake	29.80
Husks	7.85
Dust and impurities	7.90
Moisture	12.35
Total	99.87

In Cochin-China and Annam the chief food products made from Soya are vegetable milk and vegetable cheese.

The milk is obtained by crushing the previously well-soaked seeds and then macerating in about ten times their weight of water, thus obtaining a thick milky liquid. Cold water must be used, as otherwise the vegetable albumen will be coagulated and cannot be extracted.

This milk should be filtered and drunk fresh or used for making different sorts of cheese, as in the case of cows milk or goat's milk, while the compressed cake left after filtering, forms a nourishing fodder for animals.

To make the cheese, the vegetable milk is treated with a mineral salt, or an acid, which acts the part of rennet, coagulating the milk into a curd, which is drained and washed like the curd from ordinary milk.

In Indo-China the milk is coagulated by boiling and by the addition of a powder called *Tchach-Kao*, which consists of a calcined selenite. A very small quantity of this causes the complete coagulation of large quantities of milk.

The cheese is usually consumed fresh on the same day it is prepared, but can also be preserved by smoking and by salting.

In Annam there are three principal varieties of this cheese: 1. The fermented variety, of a gray or yellow color, and a taste suggesting Roquefort. 2. The white or salted variety, resembling goat's milk cheese. 3. The cooked or smoked variety, which looks like Gruyère.

At the market of Saïgon the Chinese sell these white or cooked cheeses to the natives at the modest price of 10 centimes per livre. This is about 1/10 the price of Gruyère, which indicates the economic value of this highly nutritious food and suggests the possibility of its future commercial importance.

For purely industrial applications it is necessary, as we have said, that the vegetable casein be entirely free from fatty matters.

In the industrial treatment of Soya, therefore, the process is somewhat different. The three objects sought are: the pure oil, the casein entirely free from oil, and the residuary cake.

The oil is extracted by pressing, and two grades are obtained. The first or purest is sold for edible purposes, while the second is useful for soap-making and other manufactures where oils and fats are employed. The first-pressure oil is worth about 1.5 francs per kilo, while the second-pressure product brings only about 0.7 francs per kilo.

The pure casein is prepared from the pulp which remains after the extraction of the oil. The milky liquid obtained by triturating the pulp with cold water, is filtered and treated with powdered gypsum. About 1 kilo of gypsum per 1,000 liters of the liquid is used. The mixture is brought to a boil and the resulting coagulate is drained and washed in cloth filters. The casein thus obtained is dissolved in a quantity of very dilute soda solution, so weak that the reaction is either neutral or very slightly alkaline. The solution is filtered and then precipitated by acetic acid. The finely divided precipitate obtained is filtered out, washed on the filter and finally dried at a low temperature.

The casein thus obtained is white, and, from an industrial point of view, very pure. It is insoluble in water, but soluble in dilute caustic alkalies and in ammonia. It exhibits almost precisely the same properties as the casein obtained from ordinary milk. It is found on experiment to be susceptible of the same industrial applications as animal casein, and may come to largely supersede this because of lower cost.

Among the various uses to which it may be applied we may mention its employment in painting, and for the preparation of products having a resistance to moisture.

It may be used also for the sizing of paper, which consumes such large quantities of ordinary casein. Being soluble in ammonia and caustic solutions it is capable of forming a smooth and solid size.

Other uses are in certain manufacturing processes in the preparation of silks and artificial textiles, as well as of rubber, leathers, plastic materials, films, photographic emulsions, etc. Large amounts of animal casein are at present employed in the manufacture of *"galalith,"* from which are made numerous objects which imitate articles made from ivory, tortoise-shell, bone, horn, etc. The Soya casein, when free from fats, is equally well adapted for these purposes.

Formol acts upon this casein in the same way as on ordinary casein, rendering it insoluble. Hence it may be used for the water-proofing of fabrics, straw hats, etc., as well as for the preparation of sizes and dressings.

Chevalott gives a formula for the foregoing purpose.

To 40 parts of casein in 200 parts of water is added dilute milk of lime (1 part CaO), 20 parts of soap, and 240 parts of water. The fabric is impregnated with this solution and then dried, afterward being passed through a bath of aluminium acetate. It is then washed with water at 90 deg. C. and dried.

Straw, which is impregnated with an ammoniacal solution of vegetable casein, then dried and finally subjected to formaldehyde vapors at a temperature of 80 deg. to 90 deg. C., becomes impermeable to water.

A solution of vegetable casein and borax can be successfully utilized in the process of calico printing.

It will be seen from the foregoing résumé, that the fabrication of vegetable casein for industrial purposes has immense possibilities, only exceeded in importance by the alimentary value of its food products for man and for beast.

The residuary cake left after the extraction of both oil and casein still retains sufficient nutritive qualities to be useful as an addition to the feed of animals.

Simple Tables for Calculating Circumferences and Areas of Circles.

THE simple tables given herewith may be used for calculating the circumference and area of circles without multiplication. The first table for the circumference of circles gives the value of π for diameters from 1 to 9 inclusive. To use the tables for larger numbers, proceed as follows: Suppose the circumference of a circle 32 inches in diameter is required: Change the decimal point of 9.4248 one place to the right and underneath write the value of 2 taken from the same column. The sum, or 100.531, is the circumference for a circle 32 inches in diameter. In the same way, the circumference of smaller or larger diameters can be obtained by simply changing the position of the decimal to the left or right according to the number of places. In the case of a number having four places, four numbers will be obtained to be added. Example: Find the circumference of a circle 3,486 feet diameter.

Circumference for diameter.....	3,000 =	9424.8
Circumference for diameter.....	400 =	1256.4
Circumference for diameter.....	80 =	251.3
Circumference for diameter.....	6 =	18.8
		10951.3

The table for finding the areas of circles is used in the same manner except that the diameter of the circle must first be squared and then the areas taken from the table and added as directed for obtaining the circumferences. Example: $12^2 = 144$.

Area for diameter.....	100 =	78.54
Area for diameter.....	40 =	31.416
Area for diameter.....	4 =	3.1416
		113.0976

CIRCUMFERENCES OF CIRCLES.

$1\pi = 3.1416$	$6\pi = 18.8496$
$2\pi = 6.2832$	$7\pi = 21.9912$
$3\pi = 9.4248$	$8\pi = 25.1328$
$4\pi = 12.5664$	$9\pi = 28.2744$
$5\pi = 15.7080$	

AREAS OF CIRCLES.

Area diameter.. 1 = 0.7854	Area diameter.. 6 = 4.7124
Area diameter.. 2 = 1.5708	Area diameter.. 7 = 5.4978
Area diameter.. 3 = 2.3562	Area diameter.. 8 = 6.2832
Area diameter.. 4 = 3.1416	Area diameter.. 9 = 7.0686
Area diameter.. 5 = 3.9270	

[The same expedient may be profitably employed for transforming English and metric measures.—EDITOR.]—*Machinery.*

Synthetic Rubber

IT must be a long time, says the *Journal* of the Royal Society of Arts, before synthetic rubber seriously affects the price of rubber, but it has to be reckoned with. Dr. Gerlach has been giving his views on it before the Rubber Commission recently appointed by the German Colonial Agricultural Committee, and they are worth noting. In the beginning Dr. Gerlach was sceptical as to its value, and was very much surprised when bulk samples satisfied him that synthetic rubber possesses the essential properties of high-grade material. The raw material of synthetic rubber is itself a manufactured article, the production of which, on a large scale, can only be undertaken by a few chemical firms, but there can be little doubt that artificial rubber will eventually appear on the market as a commercial product. Dr. Gerlach thinks that makers will take care that the output is not on a scale sufficient to depress the price of rubber. However that may be, producing costs will have to be largely reduced before serious competition with natural rubber is possible.

How Radio-Activity Is Measured

The Methods Used to Detect and Measure Radiation

THE discovery of radio-activity has upset the physicists' conceptions regarding the constitution of matter and has opened an entirely new and very wide field for the investigations of experimenters. It is believed it will be of interest to indicate here in a general way the methods of research in use at present for discovering and measuring the active properties of various bodies.

We shall at first briefly indicate the principle of the methods employed most frequently in laboratories, and at the end we shall explain the method of "gaging radium by measuring the emanation discharged" which has been indicated quite recently by Madame Curie.

It is well known that the phenomenon of radio-activity was discovered by Henri Becquerel in 1896. This scientist had placed a photographic plate in an opaque holder of black cloth closed at one side by an aluminium plate; a thin sheet of a uranium salt was held on the metal by paper bands; after an exposure of several hours in darkness, development showed the outline of the crystalline sheet on the negative; the silver salt had been reduced by the uranium compounds.

This method, which is almost entirely qualitative, is still used at present in order to discover a radiant source of some intensity. A photographic plate is put in a wooden box blackened on the inside and perfectly light-tight; the particle of the substance to be tested, carefully wrapped in black paper in order to avoid chemical action due to contact, is placed on the sensitive layer (Fig. 1). After an exposure of more or less length, the plate is developed to ascertain the presence or absence of an impression.

Another method, essentially qualitative, consists in

Fig. 1.—Besquerel's Experiment. A Radio-active Substance Acting on a Photographic Plate in the Dark.

exposing a fluorescent or phosphorescent screen to the action of the substance to be studied; the sensitive substance consists generally of platinocyanid of barium, or zinc sulphide, which is spread in powdered form upon the screen, previously impregnated with a weak solution of gum.

In order to indicate the activity of a substance with accuracy, electroscopes or electrometers must be resorted to.

The electroscope used as a rule is of the type having gold leaves or aluminium leaves. This is a demonstration apparatus so well known that we shall not give here any description of it, nor the manner of using it for electrostatics. For the researches we are dealing with, we combine with the electroscope a condenser, formed by two metallic plates, *A* and *B* (Fig. 2). *A* is connected with the rod *T* carrying the leaves *FF* and insulated from the box *C* by insulating corks *a* and *b*; the plate *B* is connected with the box *C*, the latter being grounded.

It is well-known that radio-active substances possess the property of ionizing the gases in their vicinity, that is to say, to render them electrically conductive. This being so if a thin layer of a radio-active body be spread on the plate *B*, and the electroscope charged, the complex formed by the rod *T*, the leaves *FF* and the plate *A* will be brought to a high potential, whereas *B* will be at the potential of the grounded box *C*, that is to say, at zero. Electricity will thus pass from *A* to *B* through the ionized gas and will be dispersed in the earth. There will be a leakage of electricity from the apparatus and the previously diverging leaves *FF* will fall together. The quicker they fall, the greater must be the leakage, that is, the more must the air be ionized between *A* and *B*, and the greater the activity of the substance spread on the plate *B*. If the apparatus has been standardized by means of a body of known intensity, such as uranium or radium, the rapidity with which the leaves will fall will afford a means of measuring the relative radio-activity of the substance under investigation.

The electroscope is a very simple apparatus, easily constructed with the ordinary means at hand in the most modest of laboratories, yet capable of yielding results of quite sufficient accuracy (within 2 or 3 per cent) in the hands of experimenters used to handling it.

The quadrant electrometer also is a well-known instrument of which we shall here mention only the chief elements: an 8-shaped aluminium needle *G* (Fig. 3) is suspended at its center of gravity *o* by means of a wire *f* the lower end of which dips into a vessel filled with sulphuric acid, while at the top the wire terminates in a hook *c*. This hook fastens the apparatus to a doubled cotton thread. The needle *G* is thus movable about a vertical axis in a closed cylindrical

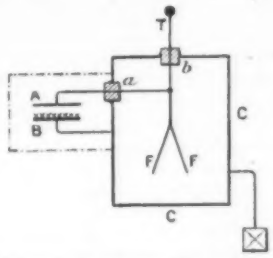


Fig. 2.—Measuring Radio-activity with a Gold-Leaf Electroscope. The Substance to be Studied is Put on the Plate B.

box, divided into four quadrants along two diametral planes, perpendicular to each other. The quadrants Q_1 and Q_3, Q_2 and Q_4 are connected in pairs by wires. Through the medium of the conducting sulphuric acid, the needle *G* is brought to a high potential by means of a battery *P*, one pole of which is grounded. The apparatus is properly adjusted when the needle, after being charged, is not deflected when the two pairs of quadrants are brought to the same potential. If the pair, Q_1 Q_3 is brought to a potential different from that of the pair Q_2 Q_4, the needle will be deflected

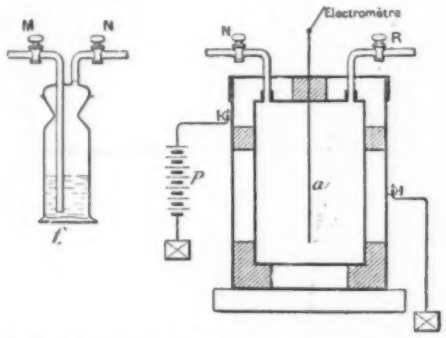


Fig. 6.—Measuring the Emanation According to Madame Curie's Method.

through a certain angle, which is read off by an optical method, on a graduated rule, by means of the mirror *M*. By first standardizing this rule, its readings may at once be translated into volts.

The *modus operandi* will now be easily understood. The substance to be tested is spread on the plate *B* (Fig. 4) of the condenser *A*, *B* described above (Fig. 2); this plate *B* is connected with one pole of a battery P^n whose other pole is grounded. The plate *A* is connected with one pair of quadrants Q_1 Q_3, the other pair being grounded.

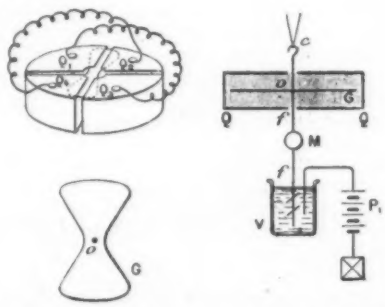


Fig. 3.—Quadrant Electrometer and its Arrangement for Measuring Radio-activity.

At the beginning of the experiment, the interrupter *I* is closed; the two pairs of quadrants are grounded. As soon as the interrupter is opened, the pair Q_1 Q_3 is insulated and receives a charge coming from *B* and passing through the ionized air between *A* and *B*; when the needle *G* has come to rest, its deflection is read; the more radio-active the substance spread on the plate *B*, the greater the deflection of the needle.

The quadrant electrometer is rather difficult to handle, and is fairly expensive. Moreover the type described above comprises a capacity (the sulphuric acid), which is prejudicial to its sensitiveness. Therefore, in practice, this electrometer has been modified in numerous ways.

With the most perfected apparatus, it becomes possible to detect even such traces of substances as the spectroscope itself would not be able to show; for the electric method is indeed, several thousand times more sensitive than the spectroscopic method.

All the measuring processes explained above bring into play the same substance which is to be examined. It is well known, however, that radio-active bodies

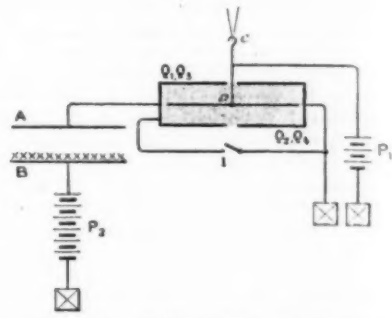


Fig. 4.—Measuring Radio-activity by Means of the Quadrant Electrometer. The Substance Investigated is on the Plate B.

emit gaseous products, having clearly defined active properties. If, for instance, in a tube *tt* (Fig. 5) we place a dish *n* containing thorium hydrate, blow inert air through said tube and cause such air to then strike the ball of an electroscope (*T*) charged with electricity, the electroscope will be discharged. These active gaseous products are known as emanations. Dissolving an active substance in a liquid is likewise attended by emanations.

Experiment has shown that the amount of emanations *q*, emitted by a radio-active body of the weight *p*, is in direct ratio to such weight: that is to say, we may write $q = Kp$, *K* being a constant.

Let us assume that we have prepared a solution of a radium salt containing a weight *P* of radium per cubic centimeter of liquid, and that it yields an emanation represented by the quantity *Q*. If then we collect an emanation represented by the quantity Q^1 from a solution containing an unknown weight X of radium per cubic centimeter, we have the two equations: $P = KQ$, and $X = KQ^1$.

Dividing the second equation by the first, we have $\frac{X}{P} = \frac{Q^1}{Q}$, from which follows $X = \frac{PQ^1}{Q}$.

If therefore we can measure the two quantities *Q* and Q^1, the unknown weight *X* can be determined readily.

Several methods have been proposed for this purpose: Madame Curie has indicated the following. A few cubic centimeters of a radium salt solution are placed in a bottle *f* (Fig. 6), through which air may be made to bubble. By a pipe having a cock *N* the air charged with the emanation from the solution can be conveyed to a gas condenser (shown at the right in Fig. 6), which has a volume about twenty times as large as that of the bottle. One of the condenser sections is grounded, the other is connected with one

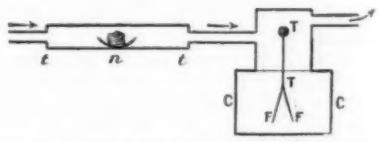


Fig. 5.—Electroscope *FF* Measuring the Radio-activity of Air Charged with an Emanation by Passing over Thorium Hydrate on Dish *n*.

pole of a battery *p*, the other pole of which is grounded. The electrometer is connected with the needle *a*. The emanation from the bottle *f* is conveyed into the gas condenser by producing a vacuum in the latter. For this purpose the cock *N* is closed and the condenser is placed in communication with the vacuum pump by opening the valve *R*. Then the valves *R* and *M* are closed and the cock *N* is opened, causing the air charged with emanations to be sucked from the bottle *f* into the condenser. *R* will remain closed to the end of the experiment. After equilibrium has been established, the pressure within the complex

formed by the bottle and the condenser will still be below atmospheric pressure; therefore, by closing the cock *N* and opening the valve *M*, air may be introduced again into the bottle *f*, and by manipulating the valves as described above, an additional amount of emanation may be caused to pass from the bottle *f* to the condenser. This operation is repeated a sufficient number of times and finally atmospheric pressure is established in the entire apparatus by opening the cocks *M* and *N* at the same time. After the entire emanation has passed from the bottle *f* to the condenser, a difference of potential is created between the sections of the condenser and the deflection of the electrometer is noted, as explained above. From the strength of the current thus obtained, the value of the amount of emanation collected is deduced by a simple formula.

Madame Curie has obtained good results by using three aspirations and three re-admissions of air in five minutes, followed by ten minutes' passage of a uniform air current.

The method just described permits of ascertaining amounts of radium as small as 10^{-9} gramme, that is, one one-billionth of a gramme.

These latest results show the fecundity of this entirely new science whose birth occurred scarcely fifteen years ago. Not only has it followed its own development in its own direction; but, coming to the assistance of other branches of physics and of chemistry, it offers even at this time methods of analysis whose sensitiveness and precison would have been thought unattainable under previous conditions of the science.—André Conté in *La Nature*.

A Scientific Use for the Stereoscope

To Aid the Imagination in Picturing Space Models

THE stereoscope is familiar to all as a means of recreation, which may at the same time be made more or less instructive according to the subject chosen for presentation. Another remarkable use which has been made of the instrument, is to enable us to actually see in solid form, astronomical objects which are far too remote to appear to us in this, their true light, by our unaided senses. It might be said that in such a case the function of the spectroscope is to supplement our limited "imagination" in the formation of a realistic image of the object.

Astronomy is not by any means the only field of science in which we can derive profit from such images. Mr. A. H. Stuart, in a recent number of *Knowledge*, illustrates a number of cases in which the stereoscope comes to the aid of the student of geometry, mineralogy and chemistry. The author says:

"Students whose geometrical studies have been confined to the geometry of two dimensions frequently find considerable difficulty when problems in three dimensions are presented to them. Ordinary drawings afford very little help and there remain only two methods by which assistance may be offered, viz., models and stereoscopic drawings. Of these the latter are undoubtedly the easiest and cheapest to produce.

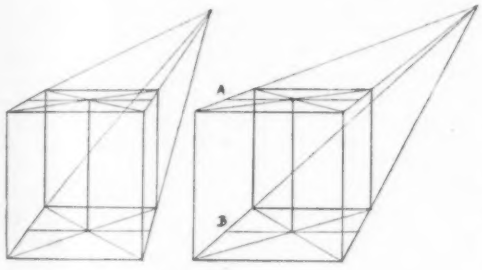


Fig. 1.—Stereoscopic View of a Cube.

The most elementary knowledge of perspective is all that is required to make stereoscopic drawings of all the usual problems in solid geometry. Fig. 1 shows a simple method of drawing a cube in perspective. A figure is drawn for each eye, the vanishing point of the figure for the right eye being separated from that of the figure for the left eye by a distance about equal to that between the two eyes. (In adults this is about 3 inches, while in boys of about fifteen years of age I have found the average to be about 2.5 inches). For all practical purposes the front face of the cube may be represented by a perfect square. The figure also shows the method of obtaining the axis of the cube. It must be remembered that the geometric center of a face is not necessarily the stereoscopic center. If the point of intersection of the diagonals is taken, no mistake can be made. Similarly, to obtain the middle point of an edge, draw a line parallel to an edge which is at right angles to the former through the point of intersection of the diagonals. This will cut the edge at the required point. Thus, in Fig. 1, *A* and *B* are the stereoscopic centers of the edges on which they stand.

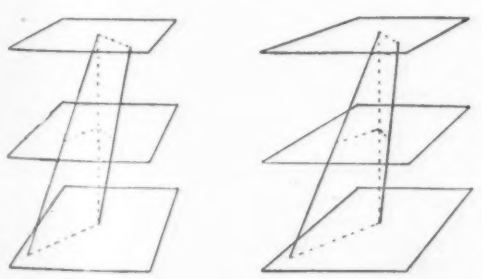


Fig. 2.—The Stereoscope as an Aid in the Study of Geometry.

"I have found it convenient to make the drawing first on a large piece of drawing paper and then prick through the necessary parts on to the paper which is to form the finished slide. This not only has the advantage of not showing the construction lines in the stereoscope, but a large number of figures of different subjects may often be pricked off the same drawing. From the cube a vast number of figures may be derived by the exercise of a very little ingenuity.

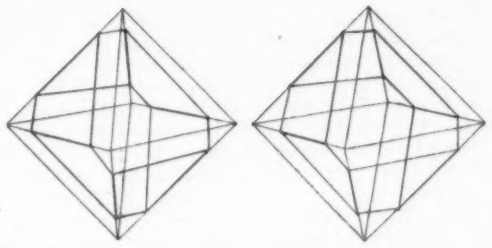


Fig. 3.—The Stereoscope as an Aid in Crystallography.

"Fig. 2 represents the figure of a well known theorem in geometry. By examining this drawing in the stereoscope the figure stands out in relief in a most striking manner, and brings home to the mind of the student the whole meaning of the theorem at once. The construction of these figures by the student is quite an education in itself, in addition to providing him with figures equal to models in every way.

"Nor does the mathematical student monopolize the benefits to be derived from the use of the stereoscope. Fig. 3 shows how an ill-formed crystal of the octahedral system is derived from the perfect octahedron; a matter which is by no means clear to every student of chemistry. Again, Fig. 4 shows the graphical formula of one of the optically active forms of tartaric acid. For obvious reasons, if a figure requires lettering only one of the figures should be lettered.

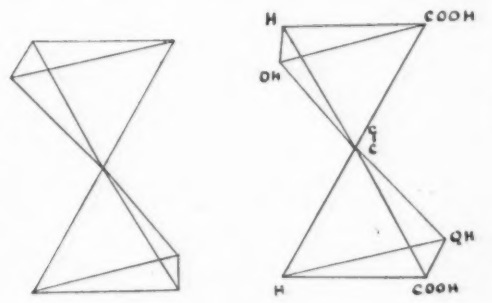


Fig. 4.—Stereoscopic Representation of the Space—Formula for Tartaric Acid.

"I have found stereoscopic drawings of geometrical solids very useful in demonstrating to physics students the theory of sterescopic vision. It is perfectly obvious to them that the two drawings of the solid are not alike, and yet, when their images are superimposed by the lenses of the stereoscope, they give the idea of relief as plainly as the solid itself would do."

Self-Burning Limestone in Syria*

From Deputy Consul John D. Whiting, Jerusalem.

WHILE making a trip through the Hauran district recently the writer's attention was attracted to a curious stone which might be described as a "self-burning limestone." Our party came upon some natives burning it and was enabled to see the operation.

At this place the rock lay in a stratum between ordinary limestone; it was of a grayish black color, and when freshly broken had an odor of petroleum. Near by were outcrops of what looked like the same material many rods long and 20 to 30 feet thick.

METHOD OF MAKING THE LIME.

The quarrying is easily done with primitive picks and other tools, as the rock is quite soft and full of seams. The stone is broken into small pieces with hammers and piled up against the bank of rock. A wall of the same material about 2 feet high is roughly laid up around the pile on three sides, making a pile of small stone 8 to 10 feet long and nearly as wide, and 2 feet at the front, rising to nearly three times that height at the back where it lies against the bank.

In building the wall around the pile small holes are left for draft and in which to start the fire. When the kiln is ready to burn, a few small bunches of straw are placed in the holes mentioned, lit with a flint and steel, and in a short time the whole pile has ignited. The men then begin working on a new kiln while the other burns and cools.

After about 12 hours of burning the stone has all become converted into lime, except the stones in the wall and the very top layer, which are only about half burned. When cool the lime is air-slaked and sifted to remove any pieces not thoroughly burned, when they are thrown into a new pile to be fired again.

While there we saw four kilns in all stages of the process except the firing. The workmen told us that it made a very black smoke with a bad odor like kerosene burning. The lime is white and said to make a very strong plaster, superior to the ordinary lime burned with brush, but sells at a much lower figure, because of the low cost of production. We were informed that in this district great quantities of lime are made in this way, and in places many gangs of men could be seen working at it, which tended to convince one of the quantity of this material which must exist. This stone is so located that, should it prove to be of commercial value, it could be easily transported.

[Samples of the stone and of the lime will be loaned to interested firms on application to the Bureau of Manufactures.]

* Published in the "Daily Consular and Trade Reports."

The Lost Art of Tempering Copper

THE Aztecs, Toltecs and Tarascans, it is said, possessed in prehistoric ages the art of tempering copper. Several archæologists and ethnologists of Mexico City now deny they had such knowledge. Copper axes and knife blades found at Atcapotzalco are so soft they can be cut with an ordinary pocket-knife. One the other hand, Tarascan copper cutting implements from the Balsas River ruins in Guerrero were so hard that they would turn the edge of a modern knife. Analysis showed that these different blades were of the same composition as the copper ores found in the respective localities. The soft blades were made from comparatively pure copper ores, while the hard, apparently tempered, blades from Guerrero, were made from the natural ores which existed in the hills, alloyed with nickel and cobalt; thus making the smelted metal (or alloy) almost as hard as steel. Hence the so-called tempering was due to the natural alloy found in the ore, which when heated and sharpened gave a hard, cutting edge. On the other hand, where the ores were practically pure copper, the implements made from such ores were soft and remain so to this day.—*Brass World*.

Sodium Nitrate Substituted for Iceland Spar

CRYSTALS of sodium nitrate have been exhibited recently at Paris, so pure and perfectly formed that they can be substituted for calcite in optical instruments. It is expected that these crystals can soon be furnished in such form as to meet all the requirements and thus relieve the instrument makers of the difficulties due to the control of the Iceland spar supply by a monopoly.—*Ind. Chim.*

Practical Aspects of Printing Telegraphy—IV*

An Inventor on the Difficulties to be Encountered and the Way to Overcome Them

By Donald Murray, M.A.

Continued from Supplement No. 1858, page 100

VARIETY AND IRREGULARITY OF TELEGRAPH TRAFFIC.

A SPECIAL difficulty for printing telegraphs is to be found in the variety and irregularity of telegraph traffic, which varies greatly in volume and in character according to the circuit and the seasons. In Great Britain, for instance, the telegrams from the Channel Islands are largely telegrams about early potatoes and other produce, and they are in many cases "multiple address" messages—sometimes two addresses, sometimes three, sometimes a dozen or twenty. Other circuits have heavy fish-traffic, such as Grimsby. Others, like London to Brighton, are largely social and domestic. There are great variations of traffic according to the seasons, and much more traffic in summer than in winter, at any rate in Great Britain. There are also great variations in the volume and kind of traffic according to the hours of the day. British telegraph traffic divides itself quite distinctly thus:—

7 to 9 A. M.—Fish and meat telegrams (provision market work).

9 to 11 A. M.—Births and deaths and a little Stock Market.

11 A. M to 1 P. M.—Stock Market and commercial messages.

1 to 4 P. M.—Racing, betting, and ordinary telegrams.

4 to 5 P. M.—Ordinary messages.

From 6 P. M. onwards.—Press messages.

The work is quite distinctly divided in this way, and the telegraph operator can watch the habits of the people, when they get up, when they start work, and so on. The number of betting telegrams in Great Britain is very large, especially from Ireland. There will be a considerable loss of revenue to the British telegraph service when the law finally puts a stop to this betting vice. There are similar irregularities in the traffic between Great Britain and the Continent. For instance, from 8 to 10 A. M. Berlin has a lot of traffic to send to London, and London has little to send to Berlin. From 10 A. M. to noon the flow is about equal in each direction. Berlin begins to slacken down after midday and remains slack till after 4 P. M. After noon London sends more than Berlin. On fish circuits in Great Britain, Grimsby and Aberdeen are very busy from 7 A. M. onwards, both with railing fish and prices. Queenstown and other big ports are busy all night with arrivals and departures of boats. Each boat arrival at Queenstown means, perhaps, 100 messages to large hotels and friends.

MULTIPLE ADDRESS MESSAGES.

It frequently happens that the same telegram has to be sent to a number of different people. These are known as multiple address messages. One source of such messages is pigeon-flying. This sport is very popular in England, and during the pigeon Derby, pigeon are sent from all over the country to one place and liberated. As many as 900 to 1,000 telegrams are sent off to the various owners of the birds, mentioning the time of liberation and the direction of the wind. The text of these messages is the same in all; the addresses only vary. These addresses are usually given to the post office a day or two beforehand. They are received in the head telegraph office in London and copied out on thin telegraph forms and kept in readiness. At the time when the pigeons are liberated a single telegram comes through to the London telegraph authorities, who promptly start manifolding it in batches of six or more on the previously addressed message forms. The filled-in messages are then sent from London by telegraph all over the country to the given addresses. Obviously a printing telegraph cannot do this class of work. Multiple address messages of 1,000 addresses are not common; but messages of from 6 to 12 addresses are frequent enough, especially from the Channel Islands. It is difficult to see how they could be dealt with by a printing telegraph. Sending the address and text of each separately would be too slow. The addresses could be sent easily enough, but this text would have to be typed or written in by hand with the aid of carbon paper, or hectographed. Racing and betting telegrams are also responsible for many multiple address messages. The number of telegrams sent out by tipsters and betting men in Great Britain is extraordinary. A tipster, say in London, who has been lucky enough to select two or three winning horses, advertises the fact, and so gets many hundreds of clients, to whom he sends out a multiple address message, recommending them to bet on several horses as certain winners. The addresses come through and then the text, and this text is manifolded on the addressed forms. If there was any regularity about this procedure some printing telegraph arrangement might, perhaps, be devised to deal with it by modern methods of duplicating, but the tipster's profession is precarious. During a lucky week his *clientèle* may swell into hundreds, and then after a few bad selections of horses the number of his clients will dwindle away to nothing. The tipster keeps quiet for a week or two, until his bad advice has been forgotten, or changes his address and makes another lucky hit in "spotting winners." Then up goes his reputation once more, and once more multiple address messages go to hundreds of clients. That is hopeless from a printing telegraph point of view. Hand work must come in in such cases. One of the most famous multiple address messages was that sent out by the London *Times* when selling the "Encyclopædia Britannica." That ran into 24,000 addresses.

TRAFFIC ARRANGEMENTS AND HOURS OF DUTY.

The telegraph service in all large administrations is very highly organized, and printing telegraphs introduce considerable changes, which cannot be effected without a good deal of trouble. Telegraph work is very irregular, and it is at its maximum only for a few hours a day, at least in Western European countries. Consequently it requires very ingenious and complicated arrangements of the hours of duty of the operators, and close attention to the average number of messages per operator, per hour (or more briefly, "operator averages"), to prevent waste of labor under such conditions. If, on an average of, say, three days' work, there is found to be extra pressure of traffic between two towns, then an extra channel is opened, or *vice versa* a channel may be closed. Men are shifted back or forward as the traffic requires. If two wires do not supply enough work for two operators, then one operator has to attend to the two wires, and so on. Then there may be a rush of work in the news division, and men have to be drafted in from other divisions to cope with it. Or sometimes, when there is heavy pressure of traffic between two towns, traffic may have to be diverted through other towns. Various divisions of the telegraph office in London help one another in this way. Printing telegraphs necessarily vary these arrangements considerably. In countries like Great Britain, with very heavy telegraph traffic over short distances between busy towns, the traffic arrangements are very complicated indeed. Important sittings of Parliament also involve heavy news work, and there are often late sittings. All this upsets arrangements. There is also constant pressure from above on the supervising staff to maintain good operator averages. The officials have, therefore, worries enough to keep the old-established routines going, without having them upset by new printing telegraph systems. Fortunately, the Murray automatic system fitted in rather well with the habits of the British telegraph officials, who had had long experience of the Wheatstone automatic. The best methods of organizing traffic for an automatic system were familiar to them. Some of the Wheatstone customs were a hindrance, but on the whole the Wheatstone experience was very beneficial.

On the continent of Europe there has been long experience with the Hughes printing telegraph, which handles the bulk of Continental traffic. There are plenty of skilled mechanics, and all telegraph offices of any size at all are provided with a repair workshop. On the other hand, the use of the Hughes printing telegraph at once limits the employment of new printing telegraphs unless they are of quite exceptional merit. Also in France the Baudot printing telegraph holds the field against any other system. Each country has its own arrangements and methods of dealing with telegraph traffic. The class of operator employed in each country also varies greatly. In America and Great Britain and Russia, and indeed in most other countries, female as well as male operators are largely employed. In Germany, on the other hand, male operators are chiefly employed, and they include many old soldiers, good reliable men, but as a rule not so rapid as men who have learnt telegraph work early in life. In Great Britain no record is kept of the messages as transmitted at the sending station (except the original messages as handed in), but most countries on the continent of Europe insist on a "home record." The Murray keyboard perforator tape is a good home record, and is accepted for this purpose by the German and other administrations using the Murray apparatus. Keeeping a home record, however, involves extra labor to wind up the tape.

In Germany the Hughes methods were an assistance to the Murray automatic system, and also a hindrance, just as in England the Wheatstone system was a help and a hindrance. With the Hughes, which prints its messages on a tape, it is necessary to insert special signals to distinguish the preamble from the address and the address from the text, and the text from the signature, and also to indicate the end of each message. With a page-printing telegraph these printed special symbols are not necessary, as the printing machine does the work automatically; but it was only gradually that these Hughes signals were abolished in the case of the Murray system, and not until it was demonstrated that Hughes methods applied to the Murray automatic system caused a distinct loss of time and labor. Hughes operators, when put to work on the Murray keyboards, found it difficult to break away from their Hughes habits. In England the change of telegraph forms from two kinds (one for S and one for X messages) to one form for both kinds of messages was made without difficulty, except in regard to the large "TO" that used to be printed at the beginning of the address in British telegrams. This "TO" seemed to be sacred, in spite of the fact that page-printing telegraphs must necessarily often print the address right through the "TO." After several years the G. P. O. finally agreed to omit the precious word. Other far more radical changes were agreed to quickly and without demur. These trifles all adjust themselves in time.

The differing conditions even in neighboring countries in Europe are surprising. In Germany the operators are, by law, responsible to the outside public for mistakes, and may be sued individually for damages. The government is not responsible. To safeguard themselves the operators tried an insurance scheme; but as soon as the existence of the insurance fund became known to the outside public, actions for damages became numerous and the fund soon faded away, so the writer was informed in Berlin. Now the operators prefer to trust to a personal appeal, and, as they have to deal mostly with good fellows, the appeal is generally successful. The possibility, however, is unpleasant, and checking telegrams very carefully is universal in Germany, and operators are never blamed for going slow. You can rely on a German telegram being accurate. Mistakes occur, but they are few compared with those in English-speaking countries. In Austria the individual operator is not liable for damages for mistakes. Also the "tantieme," or bonus system, prevails. They get a percentage on the number of messages they transmit. The same system is in force in the United States. The result is the "Tantieme Jäger" or percentage hunter, and the Austrian Tantieme Jäger is the nightmare of the careful German operator who wants to go slow to avoid mistakes. In Russia there is a much more pleasant and easy-going state of affairs, and afternoon tea is an established institution, as in London. In Russia the telegraph traffic flows along majestically like one of Russia's own rivers, without haste but without rest. Russia is a continent with day in the east while it is night in the west. Hence long-distance traffic in Russia flows continuously right round the clock. On such long lines there is no extreme urgency about transmission of telegrams in a few minutes. If they are delayed for an hour or so in transmission over 2,000 or 3,000 miles there is no harm done. This also tends to equalize the flow of the traffic. These conditions are very favorable for printing telegraphs, and during the last few years Russia has gone in extensively for machine telegraphy, with quite satisfactory results. On the other hand, on the long Russian lines a printing telegraph has to work through much longer hours than in England. In England there is very little telegraph traffic at night, except press messages, and the bulk of the traffic clusters round the hours between 10 A. M. and 3 P. M. The result is that a printing telegraph in England can only be used to its full capacity for a few hours a day. In Russia the machines have to work fully fourteen hours a day on many lines. They have, therefore, in many cases, to

*Paper read before the Institute of Electrical Engineers.

do about three times as much work per day as in England.

INTERNATIONAL CIRCUIT TROUBLES.

In Western Europe there are two very serious handicaps on telegraphy, and therefore on printing telegraphy. These are: (1) the comparatively small areas over which undivided authority exists, and (2) the differences in language. The prime conditions for extensive use of telegraphy are a large and well-educated population speaking one language and spread over a continental area. These conditions exist to a high degree in the United States of America, and in the United States telegraphy is making remarkable progress, in spite of the competition of the telephone. In fact, the telephone assists. There is also one language and a continental area in Canada, Russia, Australia, Brazil, the Argentine, and South Africa. When these giant world States have grown up, telegraphy will take on a very different aspect from what it has now. Telegraph traffic will be enormous; printing telegraph inventors will come into their own, and there will be printing telegraph millionaires in those days. Meanwhile the printing telegraph inventor has to wear the mended shoe, because the growth of the telegraph service is cramped by the smallness of European States like England, France, and Germany, and by the differences of language, and by the division of authority. Differences of language and political divisions have confined trade in Europe within comparatively small national boundaries, and long-distance telegraph traffic in Europe is very small compared, for instance, with the United States.

Apart from the language difficulty, the worst evil on these international European circuits is divided authority. The operators at each end of these circuits are quite independent of each other, and the officials at one end have no control over the other end of the line. Under such conditions a certain amount of friction and lack of harmony is inevitable The London operators, for instance, say that they have always to give way and do what the Continental operators want. The Continental operators, on the other hand, say that the London operators are the most obstinate people in the world. In spite of this, or perhaps because of this, there is much politeness on these international circuits, and frequent "Yes, Mister," and "No, Mister." To such an extent is this carried that a London operator remarked indignantly to the writer: "Every R Q means a sermon with these foreigners and half-an-hour's delay." If the European international lines came under the control of an American manager he would issue an order something like this: "Don't clog the wires with polite expressions. Take them for granted or send them by post. *Every signal costs money.*" Unfortunately Anglo-Saxon brusqueness gives offence on the Continent. The one desire of the English and American telegraph operators is to move the traffic, and they drop all polite formalities. The Germans are tending in the same direction nowadays, but the Latin nations stand on their dignity, and are very "touchy." London operators have been schooled into a knowledge of this peculiarity and make the necessary allowances for it; but there is a story that Liverpool got a direct Hughes wire to a certain French town. Liverpool started speaking to the operator in the French town as Liverpool was in the habit of speaking to London. The result was silence. The French operator simply left the circuit for three days. Liverpool had to send its messages *via* London as of old, and had to ask London to mediate. London was told by the French town that when competent operators were sent from London to Liverpool to work the direct wire, the French town would resume direct telegraphic intercourse with Liverpool. That is a characteristic experience on a good many Continental wires, and it does not smooth the path of the printing telegraph inventor. (To be continued.)

What Is a Locomotive's Time Worth?

Estimating the Financial Loss by Detention in the Repair Shop

THE increasing cost of locomotive repairs and renewals, which is in much higher ratio than the work done, has had considerable attention in the recent past. It has been suggested, and we think proven, that, while the heavy locomotives of to-day are unquestionably great money-makers, they are not as well designed for the work they are doing as the older locomotives were for the work which they did. If they were, the expense of repairs and renewals would not have increased an average of over 65 per cent, while the average tractive power had increased only 31 per cent, and the average number of tons of revenue freight per train load only about 32 per cent.

In estimating the importance of anything which will reduce or hold in check this growing expense, it is desirable to know more about what it involves. The cost of repairs and renewals tells only a part of the story; and perhaps the smaller part. The time lost from the moment when the locomotive is taken out of service for repairs until it is returned to service is also an expense. What does it amount to?

EARNING POWER OF LOCOMOTIVES BASED ON TOTAL OPERATING REVENUE AND TOTAL TRACTIVE POWER, YEAR 1910.

Road.	Total Tractive Power.	Total Operating Revenue, 1910.	Annual Earning of Ton of Tractive Power.	Daily Earning of Ton of Tractive Power.	Daily Earning of Locomotive of 20-ton Tractive Power.	Same for Average Locomotive of the Road.
	Tons.	Dollars.	Dollars.	Dollars.	Dollars.	Dollars.
Pennsylvania	55,117	165,941,130	3,010.70	8.24	164.80	131.84
N.Y.C. and H.R.	34,751	101,368,411	2,916.99	7.99	159.80	119.85
Baltimore and Ohio	32,125	90,763,401	2,825.32	7.74	154.80	121.52
D.L. and W.	10,146	38,924,775	3,838.45	10.51	210.20	140.83
Central of N.J.	5,923	25,640,244	4,328.92	11.86	237.20	147.06
Lehigh Valley	12,127	38,151,174	3,145.88	8.61	172.20	119.68
Phila. and Reading	13,527	46,046,152	3,404.02	9.32	186.40	122.09
Erie	20,052	49,714,022	2,479.25	6.79	135.80	97.09
N.Y.N.H. and H.	13,393	62,916,974	4,697.75	12.89	257.80	140.50
Boston and Maine	11,458	43,844,808	3,826.56	10.48	209.60	107.94
Average on Eastern Roads				9.44	188.80	124.84
C.B. and Q.	20,273	88,649,989	4,373.88	11.98	239.60	144.96
C. and N.W.	17,185	74,854,505	4,350.56	11.91	238.20	134.58
C.R.I. and P.	19,413	62,645,286	3,742.04	10.28	205.60	138.78
C.M. and St. P.	12,840	66,505,781	5,101.69	13.97	279.40	149.48
Chicago and Alton	4,027	13,505,779	3,353.80	9.34	186.80	138.23
Wabash	7,825	29,052,087	3,712.72	10.17	203.40	121.02
Santa Fe	24,518	86,971,313	3,547.24	9.71	194.20	149.53
Minn. and St. L.	1,100	4,947,284	4,497.53	12.32	246.40	131.82
T. St. L. and W.	1,273	3,772,636	2,963.57	8.12	162.40	109.62
Iowa Central	1,109	3,361,282	2,803.49	7.68	153.60	90.42
Average on Western Roads				10.55	211.00	130.84
Average of Twenty Roads				10.00	200.00	127.85

Judging by the general fact that locomotives are doing work only about one-half of the time that they are under steam, it might seem that the value of their time is not great. We are informed that there has not been any bettering of this condition, and if there is any practical way of changing it, managers would like to know it. Railway operation is largely an emergency business, requiring large reserves of power and other equipment. A railway is a huge machine for the production of transportation. Its efficiency is measured first by its promptness and reliability in transacting the business offered. A large locomotive repair account per mile run may indicate that the locomotives are kept up well, and that money is spent to avoid failures on the road. Certainly there is considerable difference between the records of various roads in the matter of frequency of locomotive failures. On the other hand, the frequency of failures may be the cause of high repair costs.

In order to arrive at some idea of the field offered for reducing expenses by better design, material, appliances, workmanship, care, water, etc., it seems desirable to take into consideration the value of time lost. In some cases, at least, heavy high-pressure locomotives go to the shops for new flues and ends sheets four times where the lighter low-pressure engines went once. Some roads are showing a great reduction in repairs on locomotives equipped with superheaters and consequent lower pressure. The instances where water purification has greatly reduced these expenses are numerous. Granting that such reductions of expense are possible, what are they worth in dollars and cents?

We have heard as low as a hundred dollars a day used as the value of the time of a locomotive; and as high as three hundred dollars, and more. Of course, many causes affect this, but averages are near enough to afford some data for this purpose. We have taken the reports of twenty roads for the year ending June 30th, 1910. The total operating revenue for the year is divided by the total tons of tractive power to get the earnings per year of a ton of tractive power. That divided by 365 gives the earnings per day; and that multiplied by the tons of tractive power of a given locomotive gives its proportionate part of the entire earnings of the road. In one column we have shown this for heavy locomotives of 20 tons tractive power, and in the last column we have multiplied the earnings per ton by the average power of the locomotives of each road.

It appears, on this basis, that the average locomotive's time on ten eastern roads is worth about $125 a day; and on western roads about $131 a day; and east and west about $128 a day. It ranges all the way from $90.42 on the Iowa Central to $149.53 on the Chicago, Milwaukee, and St. Paul, and $147.06 on the Central of New Jersey. Many causes influence this: Rates received, grades and curvatures, proportions of freight and passenger traffic, etc. It affords no criterion whatsoever of the comparative efficiency of management, but it is rather interesting, and certainly valuable for our purpose.

The average proportion of its time which a heavy locomotive spends in the shops is not available with exactness. The Chicago and North Western, which has perhaps the best record in the matter of despatching locomotives through shops, states that its heavy locomotives spend 26.9, or about 27 days a year, in the shops. Two other roads have named 23 days and 18 days per annum; but we understand this to mean only shopping for general repairs after making from 85,000 to 100,000 miles for freight engines and 120,000 miles for passenger engines. It appears to be a reasonable conclusion that the heavy engines spend on an average at least 30 days a year in the shops. On a time value of $200 a day (see table) this would mean $6,000 a year.

We may approach this in another way. Referring to the table, the average locomotive on the C., B. & Q. is worth $144.96 a day; if it spends 30 days a year in the shops, the time lost was worth $4,348.80; and, as the road has 1,673 locomotives, the total value of the time lost while undergoing repairs in a year would amount to $7,275,542. The total expense for locomotive repairs and renewals in 1910 was $3,954,303; repairs and lost time, therefore, cost $11,229,845. To this there should be added the expense of delay and detention of traffic, reserve locomotives, etc., which is very large. We have heard able managers state it to be much larger than the repair cost. This would swell the above figures to over $15,000,000. If, as we believe can be demonstrated as a general proposition, this expense can be reduced by improvements now possible in the construction of the locomotive, the provision of pure water, adequate repair facilities at all points, mechanical means and operating methods for care of locomotives, etc., twenty per cent, the saving would be $3,000,000 a year. A larger percentage of saving than this has unquestionably been realized in some locations by water treatment alone. All of this has far greater significance as applied to the future than as to present conditions. If the large locomotives are to continue wearing themselves out as they are doing, and the proportion of large locomotives grows as it has done, the situation will eventually make railway operation impossible unless these expenses can be reduced or curbed as indicated.—*Railway and Engineering Review.*

Soda Fountains for Trains on the C. P. R.

ACCORDING to the *Railway and Engineering Review*, the Canadian Pacific Railway management is considering the advisability of installing soda fountains in their transcontinental dining cars. The fountains will be of special make, designed to take up little room, but will be large enough to permit all popular iced drinks being served. It is expected that the experiment will be tried out on the Imperial Limited and Toronto-Vancouver expresses first, and if there found to be a success the fountains will be installed on shorter runs.

Newark Rapid Transit Cars

Special Rolling Stock Adapted to the Restrictions of the Tunnel

For use in the Newark Rapid Transit service between Newark, N. J., and 30 Church Street, New York city, through the McAdoo Tunnel, it was necessary to build small motor cars as the restrictions in the tunnel referred to are such that only cars of small cross-section can be operated. A design was, therefore, prepared by the Pennsylvania Railroad Company for a car 48 feet long over ends and 11 feet 8½ inches high from top of rail to top of roof. The maximum width of this car, over eaves, is 8 feet 7 13/16 inches, and over the side door threshold plates 8 feet 10½ inches.

Three doors have been provided on each side of the car, one near each end and one in the center. This permits loading and unloading of passengers at the center and ends simultaneously. The general type

Interior View of the Car.

of construction is the same as that used on all Pennsylvania steel cars for passenger service.

The experience of past years with steel cars has demonstrated the necessity of providing a strong center sill construction.

In freight service the minimum area of the center sills, selected to meet all requirements, was 24 square inches. For steel passenger cars, used in fast through trains, 50 square inches for the area of the center girders was considered necessary. For steel passenger cars for light trains in suburban service, 33 1/3 square inches was considered a minimum.

The type of cars here described being multiple unit motor cars, each car equipped with its own motors, can have center girders of somewhat smaller cross-section but should have at least as much as freight cars, for which reason an area of 25 square inches has been adopted.

This metal has been distributed to best advantage in the shape of a box grinder 6¾ inches deep over the trucks and motors, and 9¾ inches deep at the center. The top cover plate is 2 feet 6 inches wide and the bottom cover plate 1 foot 10 inches wide.

The superstructure is carried on two cross-bearers and two end sills in such a manner that any deflection of the center construction will not induce additional strains in the superstructure. The end sill consists of a curved channel securely riveted to a platform plate ¼ inch thick, and to a bottom platform plate also ¼ inch thick. These top and bottom plates are in turn securely riveted to the center construction and to the end sill diaphragms. The cross-bearers are made of bottom cover plates 5/16 inch thick by 11 inches wide, pressed diaphragms made of ¼-inch material and two top cover plates each ⅛ inch thick by 11 inches wide. All of the strains are transferred directly to the center sill construction, which is amply strong enough to prevent the pressing down of the end of the car in a severe collision, and transfers all vertical strains directly to the center plate. Platform plates extend from the end of the car for a distance of 5 feet 6 inches toward the center of the car and are reinforced by U-shape diagonal braces, so that both the direct and cornering strains are definitely transferred to the center sill construction thereby avoiding strains on the side framing which, on account of its narrowness, is not capable of resisting end strains. The main strength of the side framing is entirely below the windows and consists of a bottom side angle 5 inches by 3½ inches by 5/16 inch, a web plate 3/32 inch thick, and a belt rail 4 inches wide by 3/8 inch thick. The strength of this side girder is more than sufficiently strong to take care of any load that may be placed in the car.

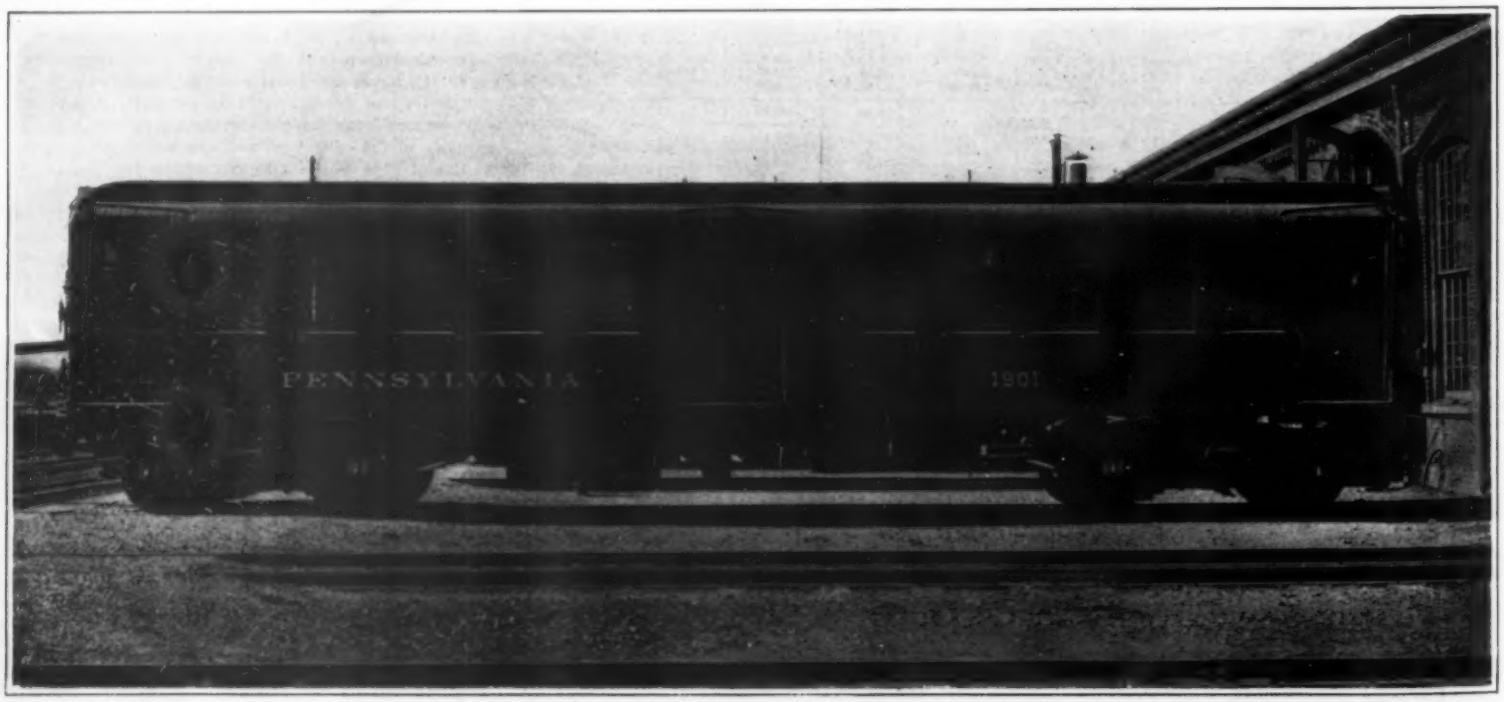
The detail construction is the same as in steam service and suburban type cars, but somewhat lighter because the car is shorter.

The interior arrangement is of the same type as generally used for interurban motor cars, with seats running longitudinally with pipe stanchions convenient as grab irons for people passing along the aisle. The flooring is magnesite cement composition with a hard surface. Directly over the center sills and platforms end plates expanded metal is riveted to the flat plates to form an anchorage for the cement. The lower deck headlining consists of steel plates and the upper deck headlining is fiber board. The longitudinal seats have metal frames and are covered with rattan. The windows consist of two sashes, the bottom one being fixed in place, and the top one arranged to drop. The deck sashes are made to open for ventilation. Adequate ventilation can be obtained by lowering the top sash of the side windows and opening the deck sash. The reason for arranging the top sash of the side windows to drop is on account of the danger of passengers putting their heads or arms out of the windows, if the lower sash is made to raise.

The drawbar is pivoted in a pocket which forms part of the center plate backing casting. The draft gear proper consists of a double coil spring placed inside of the hollow drawbar and is held in place by a cap securely bolted to the drawbar casting, being similar to draft gears used on passenger equipment cars. The springs are double acting, thereby avoiding two sets of springs usually applied to interurban cars.

In order to make these cars interchangeable with cars already in service in New York city, it was imperative to use the Van Dorn coupler, the center line of which is located 2 feet 5⅝ inches above top of rail. In the design of drawbar, draft gear and coupler head the parts were so designed that the strains are, as nearly as possible, along the center line of the parts. The center plate proper is bolted to the center plate backing casting, and between the two a pocket is provided for use of centering springs, allowing side motion of one inch between center line of car body and center line of truck; the function of the springs being to form a cushion against side strains and to provide comfort in riding.

Each truck has one motor axle and one trailer axle, and the center line of bolster is placed 2 inches out of center: that is, closer to trailer axle for the pur-



Side View of the New Car.

NEWARK RAPID TRANSIT CARS.

pose of providing the same weight between wheel and rail for all the wheels on the truck. The side frames are of H-beams with pedestal castings riveted to each end. The transom is of pressed steel and is made of ½-inch material. The peculiar shape is due to the fact that a central opening must be provided through which the body center plate must pass. The transom is rigidly attached to the side frames by means of corner gussets, which includes the brake hanger fulcrums. The bolster is placed inside of the transom and is supported by triple elliptic springs carried by spring carrier bars, passing through and flexibly hung over the transom and corner castings.

The body brake arrangement consists of two cylinder levers attached to a 12-inch by 8-inch brake cylinder. The other ends of the cylinder levers are directly connected to the equalizing bar passing through the center sills immediately above the center plate, which in turn are flexibly attached to two brake levers on each truck. The construction is of exactly the same type as that now successfully in use on Pennsylvania Railroad steel passenger equipment cars. The truck brake consists of four levers, two on each side connected to brake shoes which are hung quite low, and the levers are connected in pairs by struts, the bottom of one lever being connected direct to the strut, thereby giving correspondingly more brake power on the motor wheels. No brake beams are used. The type of brake is that known as the electro-pneumatic brake. Each car is provided with a slack adjuster to insure uniform clearance between brake shoes and wheels and, therefore, uniform braking power.

For emergency lighting, in case the power is cut off, small storage batteries have been provided to supply current.

The cars are also equipped with electrically operated door signals and electrically controlled pneumatic engines for opening and closing the side doors.

The weight of a car is 72,500 pounds.

Extinguishing Fires in Inflammable Liquids By Means of Foam.

IT is very difficult and usually impossible to extinguish fires in such inflammable liquids as kerosene, benzine and alcohol, except when the fire occurs in a tightly closed room, where it can be smothered by exclusion of air and introduction of carbon dioxide or other incombustible gas. Water is of no use because it is much heavier than the burning liquids, which therefore float upon it and continue to burn. The use of large quantities of water, indeed, often increases the extent of the conflagration. When an oil tank catches fire, therefore, all that the firemen can do is to protect surrounding property.

A recent issue of *Prometheus* describes a method of extinguishing such fires by means of foam, which has lately been devised and employed with considerable success. The foam, being lighter than the burning liquid, floats upon its surface, excluding air and thus smothering the fire. A number of years ago, attempts were made to extinguish fires with foam of various compositions, but without marked success. Recently a German firm engaged in the making of safety packages for explosive liquids has taken up and developed the process and has applied it to several accidental conflagrations and in a number of tests on a large scale with excellent results.

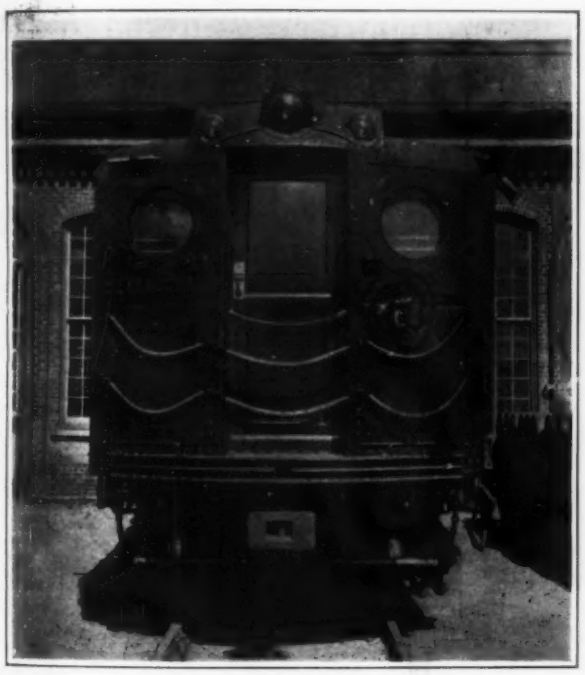
By mixing at the moment of use two liquids (usually a solution of sodium bi-carbonate and an extract of licorice) there is formed a tough light foam, the bubbles of which are filled with carbon dioxide and which can be thrown upon the fire, like water, by means of the ordinary apparatus. The foam spreads over the surface of the burning liquid and smothers the fire, its extinguishing effect being increased by the carbon dioxide. The cold foam also cools the surface and prevents the evolution of burning vapors. As the volume of foam is from five to eight times that of the mixed liquids which produce it, good results can be obtained with comparatively small quantities of material and small apparatus.

For the quick extinguishing of small fires, the firm has put upon the market the hand extinguisher "erkeo" in capacities ranging from 3.5 to 15 liters (about 1 to 4 gallons), producing from 22 to 100 liters (6 to 28 gallons) of foam. The apparatus consists of a strong steel cylinder with a short spout (having an orifice) about ⅛-inch in diameter, and provided with a safety valve. In the interior is a small glass bottle containing dilute sulphuric acid which, when the cylinder is inclined, flows out and mixes with the other liquid, producing carbon dioxide which drives the foamy mass in a powerful stream through the spout. A large quantity of carbon dioxide is thus conveyed to the fire. The apparatus can be hung up ready for instant use by any one. This hand extinguisher is especially useful for extinguishing fires in small masses of thick liquids like tar, asphalt and varnish, in solids saturated with inflammable liquids, such as oil-soaked waste and, of course, in solid objects. For lighter and more volatile liquids, such as kerosene, benzine and alcohol, the apparatus is made in another form with a long spout, from which the foam is poured upon the fire.

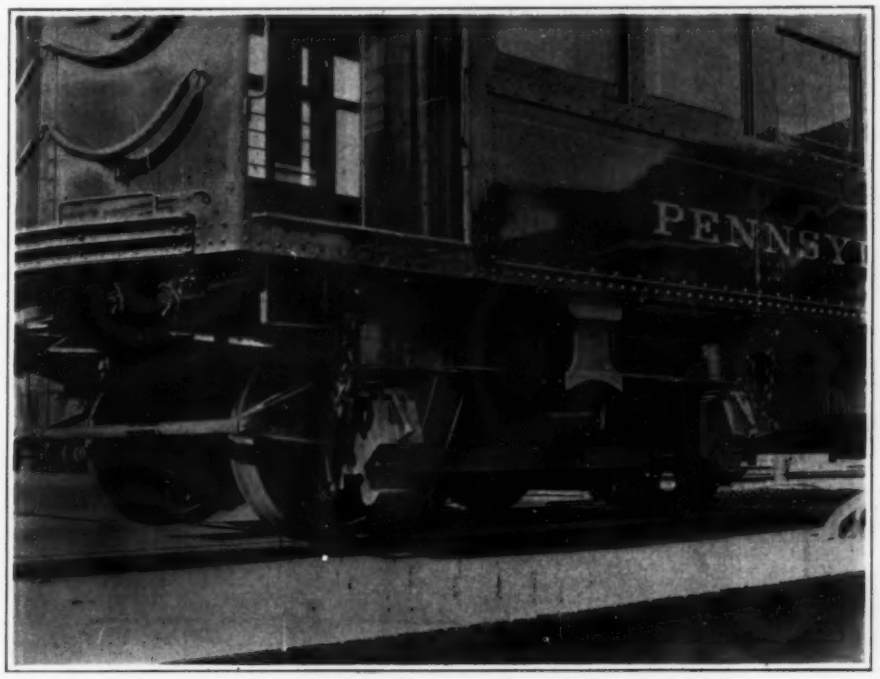
Still more effective is an apparatus in the form of a covered bucket containing about 50 liters (14 gallons) of liquid and producing 250 liters (70 gallons) of foam. This apparatus has a rubber hose about ten feet long with a large nozzle, through which the foam is blown upon the fire by means of air compressed in the bucket by a simple hand pump provided with an air chamber. The apparatus is so made that it can be refilled during use without interrupting the operation. The long hose and the possibility of varying the pressure, by pumping more or less rapidly, make it easy to apply the foam exactly where it is wanted.

A still larger form of apparatus consists of a tank mounted on wheels containing 150 liters (40 gallons) of liquid and producing 900 liters (250 gallons) of foam, which may suffice to extinguish a fairly large fire. The apparatus has a hose thirty feet long which may be extended if necessary. It is set into operation by releasing a catch and inverting the tank on its trunnions. The mass of foam is expelled automatically, as in the apparatus first described, under a pressure of five atmospheres of carbon dioxide. The horizontal range of the stream is about 80 feet; the vertical range is 50 feet. This apparatus may also be combined with a suction pump, by means of which water can be drawn from a stream or pond to complete the extinguishment of a fire after it has been checked by the foam. This form of the apparatus is especially useful on farms and in small villages, as it is capable also of arresting the progress of an extensive conflagration in the absence of inflammable liquids.

The success obtained with these various forms of the apparatus in many tests and in numerous accidental benzine, turpentine, petroleum, and carbon disulphide fires, suggested the idea of constructing fixed apparatus for large petroleum and benzine tanks. When an oil tank catches fire it is obvious that very little can be done with the small apparatus described above. It is necessary to provide apparatus of great capacity adapted to the special conditions and provided with automatic devices for setting it into operation as soon as the fire breaks out. In the apparatus which has been constructed, on these principles, the two liquids which produce the foam flow through pipes to a mixing chamber from which a pipe leads to the surface of the oil in the tank. This pipe is closed by a fusible plug which ordinarily prevents the liquid from reaching the mixing chamber, owing to the presence of air in the pipes. If, however, the oil or benzine in the tank catches fire, the fusible plug melts, the liquids mix and the foam pours out over the surface of the burning liquid and soon extinguishes the fire. In order to prevent waste of foam the containers of the two liquids are closed and communicate with the outer air only by means of tubes which pass down from their tops to a certain distance above



End View.



The Truck and Axle-Bearings.

NEWARK RAPID TRANSIT CARS.

The lighting is provided by means of incandescent lights well distributed throughout the car. The cars are heated by electric coils placed under the seats.

The motors are of the "commutating poles" type, and have a nominal rating of 225 H.P., at 600 volts. The gear is carried on the extended hub of one wheel. The front side of the motor frame is provided with two lugs which are supported by the truck transom, and the axle bearing caps are bolted to vertically planed tongued surfaces on the frame. The motor can be mounted on, or removed from, the truck when run out from under the car without the use of a pit.

The master controller is arranged to control changes of speed throughout the train and to automatically cut out the power and set the brakes, when the motorman removes his hand from the handle. It has four positions in forward and two positions in reverse direction.

The operating coils of the contractors and reversers are wound for a working potential of 625 volts. The entire control will operate successfully between 300 and 750 volts. The contractors are located below the car floor and arranged so that but one lead to circuit breaker is required. All control wires are attached to a suitable connection board at one end of the connector box. The reverser box is of iron and attached to the underside of center sills and the rheostat is composed of cast iron grids insulated with mica.

The automatic circuit breaker is provided with a magnetic blow-out for disrupting the arcs and is inclosed in an iron frame with sheet metal cover, lined with asbestos.

the surface of the oil in the tank. When the layer of foam attains this height, it closes the air tubes and stops the flow of the liquids into the mixing chamber.

A still larger apparatus of this kind has been constructed recently at the German petroleum works in Wilhelmsburg. The foam-producing liquids are contained in two large underground cisterns, whence they are forced by steam pumps into two systems of pipes so arranged that they pass near all oil tanks, storehouses and other places liable to conflagration. The two systems of pipes are connected by a number of mixing chambers from which the foam passes to a third system of pipes. The foam pipes are provided with a number of openings from some of which efflux pipes run directly into the oil tank, while others serve for the attachment of flexible hose as required.

A number of experiments have been made with this apparatus. A quantity of benzine contained in an iron tank 30 feet in diameter was ignited and this very considerable fire was extinguished in 3½ minutes.

A smaller tank open above, was also ignited. This tank leaked and some of the benzine escaped to the surrounding ditch which is required by law, and there burned. With the aid of two lines of hose the fire was extinguished in 2½ minutes. In another case, a fire in a cellar in which casks of benzine were stored was extinguished in 1½ minutes. In other experiments fires in a layer of tar of 1,100 square feet area, and in a masonry tank, 30 feet in diameter, containing 15 tons of petroleum were quickly extinguished. In the last case, the apparatus was set into operation five minutes after the fire was started, and the fire was got under control four minutes later. These experiments show the great value of this method of extinguishing fires and the advisability of equipping large oil tanks and the like with apparatus of this character, which is very much more effective than any other known means of fighting fire in such cases.

Louis Winslow Austin

Government Expert on Wireless Telegraphy

By William Atherton DuPuy

AMONG the extended investigations which the Navy Department has carried on in the field of wireless telegraphy, a series of particular interest has just been completed under the guidance of Dr. L. W. Austin, the government expert. The principal purpose of the series of tests performed, was to determine as nearly as possible the law which governs long-distance transmission of electric waves, or in other words, to establish the relations which connect the principal factors, such as distance, wave-length, height of antennæ, with the relative strength of the current at the sending and receiving stations. It has been known for some time that over comparatively short distances, the current falls off approximately in inverse ratio with the distance. It is, however, known that in addition to this decrease in simple proportion, there is a further diminution of the nature of an absorption factor. The experiments carried on under Dr. Austin's directions relate to transmission over water and by day, and under these circumstances, it was found that the absorption factor takes the form e^{-Ad} where e is the basis of natural logarithms, A is a constant for a given wave-length and d is the distance. We shall return to this point presently.

Studies in wireless telegraphy on a scale capable of leading to important and new results, are hardly within the reach of the ordinary experimenter. Such a study requires more material and means than a private operator ordinarily commands. The government, however, has a great advantage in this respect. In the course of the year 1910, the Navy Department carried on a series of long-distance wireless tests that represent the most exhaustive work of this character yet performed. The cruisers "Birmingham" and "Salem" and the great Brant Rock station near Boston were practically given over to these tests throughout the year. The primary objects of these experiments was to test the sending power of wireless apparatus that had been installed on the ships of the navy. Dr. Austin, who is in charge of the United States Naval Wireless Laboratory, took part in these tests, and studied results with relation to the possibilities of deducing fundamental laws.

As has already been indicated, the law of absorption, stated in its simplest form, is expressed by the equation:

$$I_R = \frac{K}{d} e^{-Ad}$$

in which I_R represents the received current at the antenna (through 25 ohms), and K is a constant for a given height of antennæ and a given wave-length. Expressed in words, this equation states that the received current is in first approximation inversely proportional to the distance, while the effect of absorption shows itself by the introduction of the damping factor e^{-Ad}. The quantities K and A which enter into the above equation, are capable of further analysis. Dr. L. Cohen, of the National Electric Signaling Company, discovered that the quantity A is related to the wave-length by the simple law:

$$A = \frac{a}{\sqrt{\lambda}}$$

Where $a = 0.0015$ for day transmission.

Again, the quantity K itself depends both on wave-length λ and the heights h_1, h_2 of the sending and receiving antenna, being in fact proportional to the product of these two heights. It is, of course, also proportional to I, the current at the sending antenna. The relations in question are fully expressed in the formula:

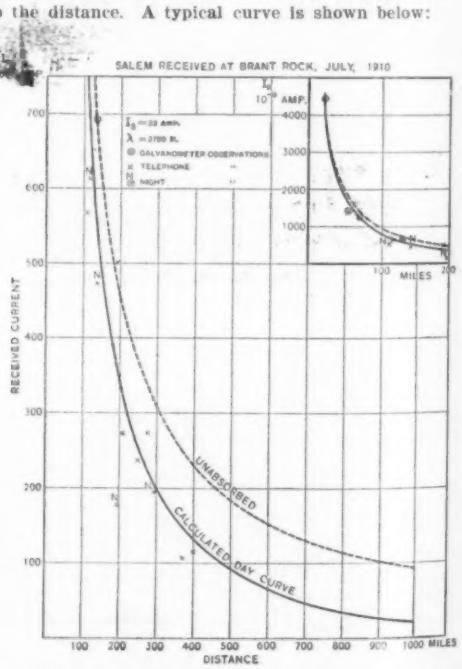
$$I_R = 4.25 \frac{I_S h_1 h_2}{\lambda d} e^{-\frac{0.0015 d}{\sqrt{\lambda}}}$$

In this equation the currents are given in amperes, and all lengths are in kilometers. The formula has been tested for sending currents from seven to thirty amperes, antenna heights 37 to 130 feet, wave-length from 300 to 3,750 meters, and distances up to 1,000 nautical miles.

Dr. Austin has constructed the actual day curve, taking into account the absorpton, wave-length, etc., and has placed this beside the theoretical curve, which merely estimates the loss of intensity as proportionate to the distance. A typical curve is shown below:

DR. LOUIS WINSLOW AUSTIN.

Government Expert on Wireless Telegraphy.



"Day Curve" Calculated by Dr. Austin's Formula. The crosses indicate the corresponding observed values.

The experiments were carried out with flat lengths antennæ ranging in height from 30 to 80 feet, and with wave-lengths of approximately 1,500 to 4,000 meters. They indicate that for the highest efficiency of a flat-top antenna, the vertical lead wires should be bunched, so as to reduce their capacity as much as possible and concentrate it at the greatest height. Dr. Austin finds that for good communication 4×10^{-8} watts must be received at the antenna, while for audible signals 2.5×10^{-9} watts is necessary.

In securing the observations upon which these findings were based, the "Birmingham" and the "Salem" were sent on various cruises from the Brant Rock station in various seasons of the year. These cruises extended as far as Liberia and to a point in the Atlantic near Porto Rico. The distances of the observa-

tions varied from 20 miles to more than 1,000 miles. Messages were sent night and day from all the distances between those figures, and a multitude of detail accumulated from which to make deductions.

The value of these formulæ is in their application to the actual work of wireless telegraphy. They lay down a scale by which may be figured the necessary height of antenna, and the necessary current in getting desired results. They give a basis for figuring the distance that may be reached with a given antenna and a given current. If the government desires to establish two stations a thousand miles apart, it will know the size and strength necessary in those stations to get results. It can estimate the distance that may be reached by the stations already established or by the wireless apparatus already installed on its battleships. The same information is also at the disposal of all those private wireless companies that have hitherto worked somewhat in the dark.

The government, for instance, has been considering the establishment of wireless communication between Honolulu and San Francisco. It is intended to attempt this in the near future. We here have definite information upon which to proceed. The government has also decided upon the establishment of a wireless station of great strength at Fort Myer, near Washington. Here three towers are to be erected. One of these is to be 600 feet high, one of the tallest structures in the world. The others are to be 450 feet high. The antenna is to be strung between these towers. It is the ambition of the government to reach out with this station to practically the whole of the Atlantic ocean and be prepared to order its ships hither and thither at a moment's notice. It is estimated that the great station will be able to send a message 2,000 miles with a reasonable dependence upon its being delivered. The new findings of the navy's expert will aid greatly in the carrying out of all these plans.

An example of the possibilities of exact calculation of the distance that may be reached by a given current as between two ships with an antenna height of 130 feet is shown in the following table:

$\lambda = 1000$ m

Antenna Current I_0	Working Distance 40.10^{-6} amp.		Extreme Distance of Audibility 10.10^{-6} amp.	
	Day	Night (Zero Absorption)	Day	Night (Zero Absorption)
1 amp.	75 miles	90 miles	200 miles	360 miles
2	135	180	300	720
3	180	270	375	1080
5	235	450	475	1800
7	280	630	550	2520
10	345	900	690	3600
15	420	1350	725	5400
20	475	1800	790	7200
25	525	2250	840	9000
30	565	2700	900	10800
40	630	3600	950	14400
50	685	4500	1025	18000
60	725	5400	1150	21600

With two stations with flat-top antennæ 450 feet high, such stations as might be constructed in San Francisco and Honolulu in the proposed attempt to establish communication, a table like the following might be expected to accomplish results. As the distance between San Francisco and Honolulu is about 2,000 miles, it appears that easy communication may be established.

Nautical Miles	$\lambda = 1000$ m	$\lambda = 2500$ m	$\lambda = 3750$ m	$\lambda = 6000$ m
1000	15 amp.	13.5 amp.	15 amp.	17 amp.
1250	38	27	27	30
1500	91	49	44	46
1750	200	95	77	74
2000	490	155	122	105
2250	.....	245	200	160
2500	.....	470	314	235
2.5	.....	.....	800	335
3000	.....	.....	775	500

In addition to all this, Dr. Austin has worked out elaborate tables as a basis for figuring out all these problems with reference to wireless stations existing and prospective. These tables are being prepared for publication by the government, and are to be given freely to the world. They will be of inestimable value to all working in wireless telegraphy. They will put the whole science on much more nearly a quantitative basis. The whole of these results will soon be obtainable upon application.

Dr. Austin had done much valuable work in wireless before his present experiments. Since 1904 he has been connected with the government Bureau of Standards, where one of the greatest bodies of scientific men in the world is stationed, and where much of advanced scientific work with a bearing on governmental affairs is being prosecuted.

Among other achievements of Dr. Austin may be mentioned his invention of a contact rectifier, which is in various forms now used in a large proportion of wireless stations in the United States.

Dr. Austin had been an instructor in the University of Wisconsin, and has been in the service of the German government in scientific work. His education was completed in Germany, and he has become recognized as one of the authorities in electrical work on two continents. He is still busy in his laboratory work for the government, and feels that the possibilities of further discoveries in wireless telegraphy are great, and is confident of vast improvement in such transmissions in the future.

The Indian Tea Industry

By EDWARD F. HARRAN, Calcutta Port Commission.

SOMETIME in the early part of the nineteenth century the tea plant (*Camellia theifera*) was discovered growing wild in Assam, a great province in the North East of British India, and, as a result, its cultivation, at first on a small, but on a gradually extending scale, was begun. In the year 1841 the first sale of Indian tea was held in London, it being on record that some 2,000 packages were offered and disposed of. Since that year the number of acres growing the tea plant has steadily extended, while exports of the article have increased proportionately until, at the present day, the trade has assumed proportions which outrival those of any other industry in the country. The principal districts in India producing tea are Darjeeling, the Dooars and the Terai in the vicinity of the northeastern extremity of the Himalayan Mountains; Chittagong Hill Tracts, on the East of India; the province of Assam on the North East and the adjacent districts of Cachar and Sylhet. In the Darjeeling district the plant is to be found flourishing at an altitude of between 7,000 and 8,000 feet above sea level, and although the bush does not attain such large dimensions here as it does in the low-lying parts of Assam and Sylhet, and is far less prolific, the tea manufactured from it is usually of a very much finer flavor than that obtained from the latter districts, and commands a far higher *average* price both at the Calcutta and London tea sales. It would be a somewhat difficult matter for anybody but an experienced planter to name the several different varieties of the plant which are now cultivated. Possibly the two original ones were those known as *Assamica* and *Sinensis*, but there are now a number of hybrid varieties giving a large and regular crop, many of which have developed under different climatic influences.

The Indian tea crop is, as has already been said, a constantly expanding factor in the commerce of the country, having been 173,988,444 pounds in the season of 1902-1903; 197,834,338 pounds in 1903-1904; 202,864,013 pounds in 1904-1905; 202,747,357 pounds in 1905-1906; 221,176,117 pounds in 1906-1907, and 213,722,195 pounds in 1907-1908. (The slight decrease in the latter year as compared with the year immediately preceding it was due to the failure of the monsoonal rains in certain districts.) This output is handled mainly in two different ways. A proportion of it is consigned from the gardens of origin directly to the two Indian ports which export tea, Calcutta and Chittagong, and shipped directly from there either to London, New York or other countries in which the assignment is destined to be consumed. The remainder of the crop is railed or boated from the gardens to Calcutta, where it is sold at periodical auctions and disposed of by the buyers either to local consumers or shipped to over-sea marts. The following table shows the various parts of the world, other than the United Kingdom, which India teas were shipped to directly from Calcutta during the season 1907-1908, together with the approximate quantity so dealt with:

	Pounds.
Europe—	
Antwerp	73,205
Batoum	4,841,454
Bremen	261,285
Christiana	5,464
Constantinople	345,154
Copenhagen	5,508
Hamburg	369,625
Havre	25,785
Marseilles	9,971
Odessa	941,939
Rotterdam	103,429
Trieste	60,701
St. Petersburg	90,860
Salonica	2,400
Samsoun	2,585
Moscow (via Vladivostock)	2,235,461
Other ports	59,068
Total	9,433,894
Asia—Total	18,312,689
Africa—Total	743,430
America—Total	3,744,298
Australia—Total	10,950,982
Grand total	43,185,293

In addition to the above, during the same season 1907-1908, 9,098,504 were shipped from Calcutta to other Indian and Cingalese ports, principally Colombo.

Turning to tea handled in Calcutta itself, it may be stated that with the increase in the output of the gardens and the consequent rapid expansion of trade, there existed for many years a notable need for concentrating it in some portion of the city where it could be handled with facility and the chests expeditiously disposed of. This need was first met by the commissioners for the port of Calcutta making over one of their warehouses on the bank of the River Hooghly for the concentration of the trade, and in which the periodical tea auctions could be held. This sufficed for some years, but the rapid expansion of the industry soon outgrew the limits of that building, and in 1904 the commissioners, on the representations of the trade, resolved to build a special warehouse and equip it upon thoroughly up-to-date and model lines. The sanction of the government of India was necessary to the proposal, and it was May, 1905, before this was received. Work was at once taken in hand, the projected warehouse being designed by Mr. Frederick Palmer, C.I.E., A.M.I.C.E. (Eng.), the Chief Engineer of the Calcutta Port Commission and now Engineer-in-Chief of the Port of London, and Mr. John Scott, A.M.I.C.E. (Eng.), then District Engineer of the Calcutta Port Commission, now Chief Engineer of it. The whole of the brick and stone work of the building was constructed by the Port Commissioners' own labor, the iron work and the installation of the electric lifts being done by contract with private firms. The edifice consists of four stories, each carried on substantial rolled steel joists and supported on built-up columns of heavy section steel girders. Each floor is divided into three large warehouses, separated by solid masonry walls 20 inches thick, communicating with one another by means of fire-proof doors. The foundation work, which was rendered exceedingly difficult owing to the founds having to be laid across two old slip-ways (which necessitated a large amount of pile driving), is entirely of reinforced concrete. The whole structure measures 526 feet in length, by 122 feet in width, has a uniform height of 52 feet 8 inches, and comprises 436,300 cubic feet of brickwork alone. The warehouse was specially designed to facilitate the easy and rapid handling of large quantities of tea. One side of it abuts onto the banks of the River Hooghly, adjacent to which two commodious sheds, known as the Tea Transit Sheds, have been erected, and from and to which steamers can directly receive or discharge chests. On the other side, the permanent way of the railroad has been laid, and loaded freight cars are thus brought up right alongside the warehouse and their contents are discharged directly into it; from the bottom floor the chests of tea are conveyed to the higher stories by specially constructed electrically-driven lifts, of which there are eighteen in all. Basing the calculation on a cost of 2½ annas[1] per unit of electrical energy expended, it is estimated that the entire cost of operating these eighteen lifts is only about 323 rupees[2] per mensem, and this is in spite of the fact that the lifts work an average of over fourteen hours a day, and frequently, during the height of the tea season, seven days a week. Each lift has been tested to a working load of 30 hundredweight, is designed for a speed of 90 feet per minute, and depends for its power on a 20 brake-horse-power electric motor, situated on the top floor of the building, running at 800 revolutions per minute. A feature of the warehouse is the tea bulker, which works in connection with a tea mixer having a capacity of sixty-four chests of tea, situated on the second floor. The tea is fed into this mixed over the sides, and passing through the floor by a huge funnel in which it is mixed runs through the apex of this into four hoppers on the floor below. The cost of the entire tea warehouse and its equipment, including the railway sidings, was nearly nine and a half lakhs of rupees.[3] The total amount of tea that changed hands under the auctioneer's hammer in the warehouse during the season 1907-1908 was 73,176,885 pounds, while the total quantity that actually passed through it during the same period was 1,449,540 chests, or, at 95 pounds to the chest, 137,706,300 pounds, out of a total crop in India of 213,722,195 pounds. It will be seen, therefore, that it is no misnomer to call the warehouse the "center of the India tea trade." In conclusion, some little idea of the magnitude of the industry may be culled from the statement that the average value of the annual production of Indian tea is about six million pounds sterling, that of China about five and a half million pounds sterling and that of Ceylon between three and four millions.

[1] An anna equals one penny in English coinage and two cents American.

[2] A rupee equals one shilling and four pence in English coinage and about thirty-two cents American.

[3] A lakh of rupees equals £6,333 in English coinage and about $31,660 American.

The Formation of Mountains by Water

The Influence of Erosion by Water in Modeling the Landscape

Destructive is the action of water when it falls from a height upon the land beneath. Almost everything which comes in its path is in time levelled or swept away, and except for the existence of obstacles which oppose more or less resistance to the action of water the entire surface of the earth would be made level by this process, which the geologists call abrasion. The resistance opposed by these irregularities gives the earth's surface the diversified appearance which it now presents, and causes the formation of mountain ranges and valleys, isolated mountains, peculiar rock structures, etc. This sort of action is called erosion. Abrasion and erosion may be regarded as the negative part of mountain formation, the positive part being the deposition of masses carried from other places, the formation of deltas, piles of detritus, etc. The connecting link between the two parts is denudation, which means the transportation of loosened material, as observed in mountain torrents and avalanches.

Water in motion employs various means by which it destroys even the hardest rock. By its mechanical impact, it detaches grains of sand, stones, and even whole cliffs and river banks. The separated material is carried along by the water and its friction against the bed of the stream constantly increases the depth of the channel. In this process each fragment acquires a rounded form, which is characteristic of pebbles. Every stream tends to reduce its falls as much as possible. Where its impulsive action, its power of carrying sand and pebbles ceases, the bed is raised; while in other places the falls are gradually obliterated by recession caused by the cutting away of their edges by the water that pours over them.

Equally powerful, though less rapid, is the decomposing action of water, which is increased if not caused by various substances, which it holds in solution. Granite, gneiss and porphyry are decomposed by dissolving of one of their constituents, felspar. The other ingredients, quartz and mica, thus lose their cohesion, and are washed away and deposited in other places, form the so-called secondary deposits. This is the origin of sandstone mountains. Some granite which appears perfectly solid crumbles in the hands, owing to the loss of its felspar.

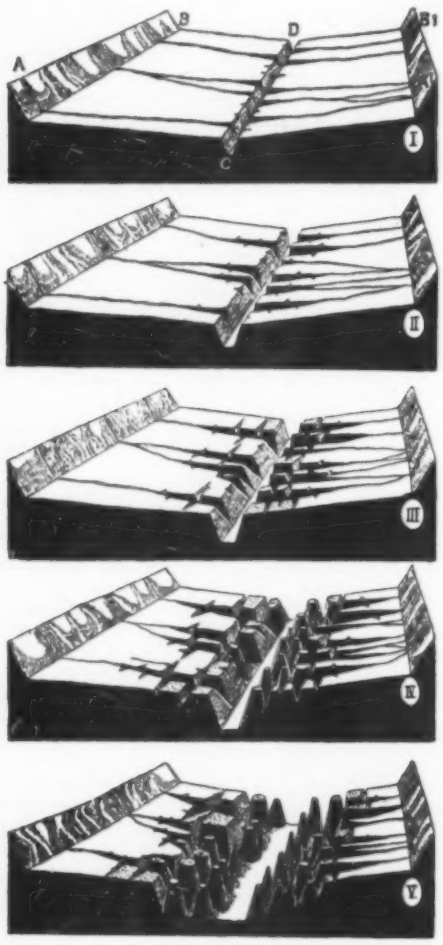


Fig. 1.—Diagram Illustrating the Formation of Earth Pyramids.

The effect upon limestone is very different. Rain water contains in solution carbon dioxide washed down from the air, which converts the insoluble calcium carbonate into the soluble calcium bi-carbonate, which is deposited in other places by evaporation of the water. Thus are produced the "Karen fields" and stalactite formations; the former by negative, the latter by positive action.

Selective erosion is probably a matter of chance; at least, the laws which govern it are not easily recognized. Hence it will be advisable to look for a natural model, in which these laws can be studied. Such a natural model is found in the so-called earth pyramids, the formation of which may perhaps be illustrated by Fig. 1. In this diagram we see a deep and wide valley bounded by the cliffs AB and A_1B_1, and filled with detritus deposited by a mountain torrent or a glacier. This material has acquired a firm consistency by a slight admixture of clay, and especially by the great pressure to which it has been subjected. In this mass a deep and narrow channel, CD, is cut by a stream. (See 1.) Smaller rivulets flowing into this river cut channels backward on both sides of the main stream by recessive erosion of its banks (II). The same process is repeated with the smaller streams, and thus the whole surface is cut into patches by intersecting grooves (III, IV). This is the first stage in the formation of earth pyramids, which are subsequently rounded and pointed by the action of rain until they assume the form shown in IV and V.

Fig. 2.—Earth Pyramids at Bozen, Tyrol.

Fig. 3.—Stone-capped Earth Pyramids at Bozen.

THE FORMATION OF MOUNTAINS BY WATER.

Now begins the process of erosion, which may be arrested by a stone or a layer of very solid soil upon which the floods pour in vain, and which extends itself over the pyramid like a helmet. The water still continues to wash away the flanks of the pyramid and cut deeply into the earth around its base, so that the pyramid continually grows taller and more slender until it becomes unable to carry the protecting stone cap. The bowlder then falls and the process begins anew.

Often, however, the stone which first protects the pyramid, subsequently aids in destroying it by converging all the rain water upon a single point, so that it cuts deeply into the side of the pyramid and causes it to collapse. If we compare this diagram with a photograph of real earth pyramids arranged regularly on a steep mountain side (Fig. 2) we see that the water pouring over the cliff above has carved the pyramids roughly from the earth and that rain has given them their beautiful rounded forms. All of the pyramids are equally slender, although they differ in height. It is worthy of note that the lowermost pyramids are the tallest.

Fig. 3, on the contrary, shows a few pyramids which are much taller than the rest, and which owe their greater height to stones which cap their summits. Other stone-capped pyramids are shown in Figs. 4 and 5.

The celebrated English geologist, Lyell, expressed the opinion that cap-stones were necessary to the formation of earth pyramids, but that in most cases these stones had fallen. According to this theory the pyramids are carved from the earth by the force of rains, which have washed away the soil everywhere except where it was protected by these cap-stones. This theory was formerly generally accepted, but, in addition to other defects, it attributes to rain an erosive power which it does not possess. Rain falling from the clouds, and water accumulated on the earth and flowing down-hill in streams, compare with each other, in point of erosive action, much as water flowing from a watering-pot through a sprinkling nozzle compares with the same water applied without the sprinkler. In the former case the water is distributed over a large surface and its force is correspondingly diminished. It is either entirely absorbed by the soil or it accumulates in depressions of the surface. If, on the other hand, the water is poured directly from the spout it cuts deep grooves in the earth because its power is concentrated in one spot. Stones or hard portions change the direction of flow while the softest places are washed away more quickly. Thus is dug a channel which the succeeding masses of water must follow, and this channel is continually deepened. The hard portions and stones check the flow and cause an increase of pressure, until the pent-up water escapes by cutting a lateral channel. If there are neither softer or harder places the erosion

Fig. 4.—Stone-capped Earth Pyramid at Oberbozen.

Fig. 5.—Earth Pyramids at Schloss, Tyrol, Meran.

channels are determined by natural elevations and depressions.

A good idea of the unimportance of stones as determinants of erosion may be obtained from a study of the earth pyramids near Bahrn in the Tyrol, where the river Eisack, after breaking through the mountain chain, traverses a wide valley filled with hard calcareous detritus. Here are found the results of erosion in various and peculiar forms: long and sharp wedges, flanked by thick blunt towers, and short slender pyramids. None of these formations is capped by a stone, although stones are abundant. Few of the celebrated earth pyramids of Klobenstein are crowned with stones. Other examples of earth pyramids which do not owe their origin to protective stones are found in the "Wissower Klinten" on the Baltic coast (Fig. 6).

This theory of the formation of earth pyramids has the advantage of agreeing very closely with the views held by geologists in regard to the formation of mountain valleys by erosion. Hence, says Dr. Ludwig Günther, who explains the theory in *Kosmos*, the earth pyramids appear to constitute excellent natural models from which the phenomena of erosion in general can be studied to advantage.

The dolomite formations, especially those of the Kewater Alps, may be attributed to similar causes (Fig. 7). Earth pyramids cannot be formed of material of every kind. If the mass is too sandy it disintegrates too quickly; if too clayey, it coheres too firmly; if too hard, it may be carved but not modeled. Similarly, sharp peaks cannot be produced from every kind of rock. There are, however, rock formations which have been produced in this way. Montserrat in Spain is composed of *breccia*, or pebbles, agglutinated by a binder. The chain of mountains, originally continuous, has been cut into separate peaks by streams of water.

An especially good material is mountain limestone, which occurs in granular masses. The peaks and combs of the dolomite mountains of Southern Tyrol have been caused by recessive erosion, produced by water falling over cliffs. According to one theory, this region was originally a coral plateau.

Other fine examples of erosion are found in the sandstone mountains of the Elbe. This region was also once a continuous plateau in which the river first cut a deep and rather narrow channel. Intersecting channels were subsequently made by tributary streams, and thus the plateau was cut up into mountains by the process indicated in Fig. 1. Another good illustration of the theory is afforded by the Suabian Alps which were originally a plateau.

This theory is almost proven by the Conical mountains near Stuttgart. These peaks are formed of volcanic rock, which filled crevasses and whose hardness preserved it, when the surrounding material was carried away by abrasion. The rock was subsequently rounded by the action of floods of rain. A "karen field," the result of negative erosion by chemical decomposition, is shown in Fig. 8. These fields are beds of limestone, which are traversed by multitudinous deep fissures which have been hollowed out by the solvent action of water.

Underground Water for Public Use.

THE U. S. Geological Survey has recently issued a pamphlet containing a number of papers on underground water, dealing with the draining of land by wells, the phenomenon of freezing wells, the pollution of waters in limestone, granites and sandy deposits, the so-called "magnetic wells" and other features of underground flow and the tapping of the same.

Concerning water flowing in limestone seams and caverns, one of these papers, by George C. Matson, states: "It is always wise to refrain from drinking underground water which contains silt or clay, for although these materials in themselves are seldom injurious they may indicate the presence of surface drainage, which has received little or no natural purification. It must not be inferred that all surface drainage is harmful, but it is well to bear in mind the possibilities of pollution by such drainage, and if any part of the surface drainage comes from a city or from dwellings the water should be rejected.

"A fact which needs great emphasis is that water which flows in channels in limestone probably receives less natural purification than surface water. Especial attention is called to this fact because there is a popular belief that water is purified by passing a short distance underground. This belief is based on a study of the purification of water by its passage through sand or sandstone. In these materials the purification is mechanical and takes place because the openings between the sand grains are very small. In other words, in removing the objectionable matter the sand acts as a mechanical filter. Water that flows through channels in limestone receives no filtration and consequently but little natural purification. It is also effectually sealed from the oxidizing effects of air and sunlight. The flow of water in limestone passages may be compared with its movement through ordinary water mains, and the chances for purification are about equal in the two channels.

"The practice of putting rubbish and barnyard filth into sinks (in the ground surface over limestone) should be abandoned. Still more reprehensible is the custom of running sewage into sinks, thus converting the underground channels into natural sewers. This practice, which is by no means uncommon, is often defended by the assertion that the water in limestone channels beneath a city is unfit for drinking even without the sewage. The correctness of this assertion cannot be disputed, but there are persons who are ignorant of the danger and who continue to use

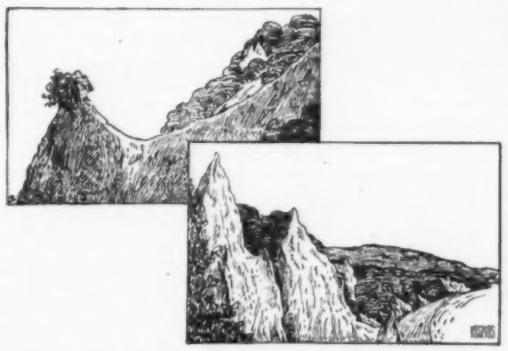


Fig. 6.—The Wissower Klinten on the Baltic Coast.

Fig. 7.—The Kewater Alps.

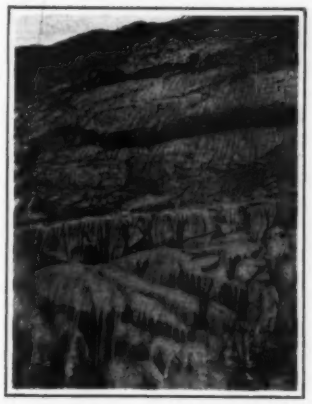


Fig. 8.—A "Karen Field" Showing Fissures Made in Limestone by the Solvent Action of Water.

the underground water. Moreover, those living at some distance from the city may use water from the underground channel which receives the sewage. For these reasons any city which proposes to convert an underground water course into a sewer should be forced to trace the channel to its destination so that others may be protected. There is need of legislation to prevent the unnecessary pollution of underground streams. Such legislation has been enacted for the protection of surface water, but the protection of underground water has been entirely neglected."

The protection of shallow wells in sandy deposits is discussed by Myron L. Fuller, who distinguishes between uniform and non-uniform sands, defining the former as sands of uniform size of grain and general structure, generally limited to wind-formed deposits known as dunes, and defining non-uniform sands as those in which there are alternate layers of porous sand and wholly or relatively impervious materials. He summarizes and concludes this discussion as follows:

"The alternation of layers of materials of different texture, even if all are pervious, and the presence of stratification planes in uniform materials tend to obstruct the downward passage of water and to confine pollution to the upper portion of the ground-water body—the part immediately below the water table. This explains why many towns located on sand deposits procure unpolluted water from driven wells sunk a few feet below the ground-water level, notwithstanding the sands receive the entire drainage of the towns. To this fact is due the absence of typhoid, cholera and other water-borne diseases at many points where danger from pollution might be supposed to exist. To insure safety, wells should be carried to a considerable depth below the ground-water level, and as each succeeding layer of material affords additional security they should be sunk as deep as possible.

"Polluted ground waters are more or less purified through the removal of their suspended matter and a portion of their bacteria by entanglement among the grains of the material through which they pass, by oxidation, and by nitrifying bacteria, but more or less polluting matter remains for a considerable length of time.

"The distance to which pollution is carried will depend on the porosity and size of grain of the materials through which it passes, the amount of rainfall, the inclination of the surface and the elevation of the outlet, the temperature, the number of sources of contamination and the amount of pollution entering the ground.

"Where a single source of pollution exists and only a small amount of polluting matter enters the ground the contamination does not commonly extend beyond 150 feet. An open well at this distance would probably give no trouble, and a driven well extending 15 feet or more below the water level is almost sure to be safe, provided the rate of movement of the ground water is normal and the pumping not severe.

"Where there are several sources of pollution and large amounts of polluting matter are introduced into the ground the contamination may extend in porous materials for some hundred or even thousands of feet, especially when the underground waters move with considerable velocity. In such places open wells are out of the question, but driven wells carried 20 to 25 feet below the water level will usually afford safe water if not heavily pumped. If the wells are heavily pumped to obtain water for manufacturing purposes or for city supply the water table is usually lowered considerably, the polluted waters likewise sinking to a greater depth. Under such conditions a depth of 50 feet or more below the normal water table is none too much."

Zodiacal Light.

SEVERAL observers have found that the zodiacal light sometimes presents very regular pulsations in intensity and form. In a recent number of the *Comptes Rendus*, Professor Birkeland finds that these pulsations correspond very closely with the periods found for regular magnetic waves in the polar regions, thereby suggesting that the zodiacal light may have an electrical origin. Several experiments are described which were undertaken in the endeavor to illustrate this view. From these it is suggested that there may be a ring of luminous matter extending in the plane of the sun's magnetic equator. Reference is also made to the Gegenschein and the formation of luminous clouds.

Seasoning Wood by Electricity.

A CONSULAR report from Birmingham, England, gives the following particulars of a new process for seasoning wood, said to be worked in France: A large tank is filled with a solution containing 10 per cent of borax and 5 per cent of resin, with just a trace of carbonate of soda. In the bottom of the tank is a lead plate which is electrically connected to the positive pole of the dynamo. The timber to be treated is stacked on this plate, and when the tank has been filled another plate is superimposed and connected to the negative pole of the dynamo. When the current is switched on it passes through the stack of wood between the two plates, and in its passage it is said to drive out the sap in the timber and deposit borax and resin in its place, completely filling up all pores and interstices. When the process is completed the timber is removed and dried, after which it is ready for use. It is claimed that the timber submitted to this treatment, no matter how green it may be, becomes completely seasoned.

The Nitrogen Question from the Military Standpoint*

Our Dependence Upon the Nitrate Supply for National Defense

By Charles E. Munroe, Professor of Chemistry, The George Washington University

THE invention of gunpowder afforded man a means of utilizing the energy of chemical separation in effecting propulsion and of more efficiently applying this form of energy in mining and quarrying. Through the discovery or invention of mercuric fulminate, the cellulose nitrates, the glyceryl nitrates, the nitro-substitution compounds, and the various explosive compositions made from these nitrates and nitro-compounds, man was enabled also to utilize the energy stored up in unstable molecules. History indicates that the invention of gunpowder was made where saltpeter, which is its chief ingredient, was naturally most abundant and most easily obtained, but that, owing to the great value of gunpowder to man, its use and manufacture spread to the cooler and more humid countries, and it is in these countries that it and the other explosives enumerated have come to be most extensively used. Statistics are not at hand by which to show the increase in the use of powder throughout the world, but some relative idea of this growth in recent years may be gained from Table 1, which sets forth the quantity, or value, or both, of the gunpowder, including, since 1860, blasting powder also, produced in the United States in each census year beginning with 1840.

The statistics for the world's production of the modern explosives are also not accessible, but an item contributing toward the assembling of this valuable information regarding the world's progress was given for dynamite as sold from the several factories with which Alfred Nobel, the inventor of dynamite, was associated, though as there were, during the period covered, independent factories in Germany, in America, and probably in other countries, these figures, as set forth in Table 2, give only a relative idea of the growth of this industry.

Table 1.—Powder Produced in the United States.[1]

Census.	Quantity (pounds).	Value.
1840	8,977,348	.....
1850	[2]	$1,590,332
1860	[2]	3,223,090
1870	[2]	4,011,839
1880	[2]	3,348,941
1890	95,019,174	6,740,099
1900	124,824,473	5,395,193
1905	215,820,144	8,919,460

[1] Chemicals and Allied Products, Bulletin 92, Census of Manufactures for 1905, by Charles E. Munroe, p. 82.
[2] Not reported.

The most complete and detailed figures relative to the production of explosives to be found anywhere are those presented in the reports on the census of manufactures of the United States for 1900 and 1905, which are as follows, the gunpowder and blasting powder, which were combined in Table 1, being presented separately in Table 3.

Table 2.—Annual Sales of Dynamite from Nobel Factories.[1]

Year.	Tons.	Year.	Tons.
1867	11	1875	3,350
1868	78	1876	4,000
1869	184	1877	5,500
1870	424	1878	6,200
1871	785	1879	7,000
1872	1,350	1880	7,500
1873	2,050	1881	8,500
1874	3,120	1882	9,500

[1] Notes on Nitroglycerin, Dynamite, and Blasting Gelatine, by George McRoberts, Phil. Soc. Glasgow April 25, 1883.

It is an interesting and important fact that, as with gunpowder so with all of the other explosives enumerated, a nitrogen-containing compound is employed in the manufacture of each and nitrogen remains as a component or constituent of each product. The quantity of nitrogen in one hundred parts of these explosives, together with its equivalent in real nitric acid and in sodium nitrate, is shown, together with other data relative to these explosives, in the following table:

In calculating the data for Table 4 the gunpowder is assumed to be composed of KNO^3, 75 per cent; C, 15 per cent; S, 10 per cent; and the blasting powder of $NaNO^3$, 74 per cent; C, 16 per cent; S, 10 per cent; but variations from these compositions will be found in practice. However, it is believed that they represent very closely the averages of all commercial compositions so styled. Although a most important explosive, dynamite is omitted from the table because the wide variations in the character and quantities of the components of this mixture as it occurs in commerce render it impossible to properly represent it by an average formula, though it is usually admitted that on the average dynamite contains 40 per cent of nitroglycerol. The wide variation in nitrogen contents occurs in the dope or absorbent, which may contain from no nitrogen-containing component whatever, as in the kieselguhr dynamites, to 60 per cent of sodium nitrate in straight wood-pulp dynamites; and this last material may be partly or wholly replaced by ammonium or potassium or cellulose nitrates in other dopes and compositions. Because of a similar wide variation in their components the compositions made from picric acid, its salts, and other nitro-substitution compounds are also omitted. Notwithstanding these omissions, it is believed that the data set forth in the table may prove useful in the development and checking of the statistics of manufacture. But, unfortunately, owing to the different manners in which the nitrogen atoms are grouped, as regards the other atoms, in the molecules of the different kinds of explosives, no direct relation is to be observed between the properties and behavior of these different bodies and the percentages of nitrogen they contain, and this want of relation becomes the more marked the larger the number of different nitrogen-containing substances that we consider. What, however, is emphasized by this presentation of data, is that the element nitrogen is a characteristic and important component of all explosives that have been accepted and used for military purposes.

Table 3.—Quantities and Values of Explosives Produced in the United States in the Census Years 1900 and 1905.[1]

		1900.		1905.	
		Quantity.	Value.	Quantity.	Value.
Gunpowder	pounds	5,450,773	$614,290	10,383,944	$1,541,483
Blasting powder	kegs[2]	4,774,948	4,780,903	8,217,448	7,377,977
Nitroglycerin	pounds	35,280,498 [3]	5,532,570	51,579,270 [4]	7,730,175
Dynamite	do	85,846,456	8,247,223	130,920,829	12,900,193
Guncotton	do	2,988,176 [5]	1,473,619	5,905,958 [6]	2,435,805
Smokeless powder	do	3,053,126	1,716,101	7,009,720	4,406,477
All other explosives	.....	.....	6,493	.....	190,948

[1] Chemicals and Allied Products, Bulletin 92, Census of Manufactures for 1905, by Charles E. Munroe, p. 80.
[2] A keg contains 25 pounds of blasting powder.
[3] Including 32,661,806 pounds, produced and consumed, valued at $4,749,271.
[4] Including 43,643,270 pounds, produced and consumed, valued at $6,110,058.
[5] Including 2,139,834 pounds, produced and consumed, valued at $1,069,917.
[6] Including 5,522,796 pounds, produced and consumed, valued at $2,209,118.

From the time of the invention of gunpowder until the middle of the last century the only recognized available source of this nitrogen was India saltpeter, which is the potassium nitrate, and which was obtained from the niter found or formed in soil or rocks. The production of nitrates in the soil or rocks is brought about usually through the agency of nitrifying bacteria. In order that the process of nitrification may go on there is required a supply of nitrogenous organic matter, a slightly alkaline medium, a temperature range between definite limits, a limited amount of moisture, a supply of oxygen or air, complete or semi darkness, and the presence of the nitrifying organisms. The nitrification proceeds most rapidly at 100 deg. F. and within a few inches of the surface of soil or rock which is well aerated and moderately moist. When potash salts are present in sufficient quantity the potassium nitrate is produced, but the native niter usually consists largely of calcium nitrate with some magnesium nitrate and other salts. All of these nitrates are readily soluble in water and may therefore, after formation, be to a great extent washed away by frequent rainfalls, but where there is only a moderate amount of water present the solution may be brought to the surface by capillarity, and as the water evaporates the nitrates will be left as an efflorescence on the surface of the soil or rock. It is evident, therefore, that accumulations of niter will be largest in those localities where not only the best conditions for its production obtain, but where also it is least likely to be washed away after being formed. The native sources of supply are therefore found as efflorescences on the soil in semi-arid countries, in limestone caverns, where the remains and excreta of bats are the chief source of the organic matter, and about stables.

Since the amount of niter procurable from these sources was limited it became necessary, as the demand for saltpeter increased, to resort to other sources of supply, and consequently niter plantations were established in many countries where, following the principles set forth above, the niter was formed and protected from the weather. Desortiaux,[1] describes in detail the saltpeter plantations of Hungary, Switzerland, France, and Sweden. Such farms have been carried on in this country, especially in the Southern States during the civil war, and the means resorted to by John Harrolson, of Selma, Alabama, to secure the necessary nitrogenous organic matter for these farms became particularly widely known. In emergencies, as in Sweden in 1520, the earth of cemeteries has been lixiviated to obtain niter, and in this last-mentioned country a tax was imposed in 1642 which had to be paid in saltpeter.[2]

About 1821 the naturalist Mariano de Rivero found on the Pacific coast of South America, in the province of Tarapaca, immense deposits of sodium nitrate.[3] As this salt had prior to this been known only as a laboratory product, the discovery was of marked scientific interest, which became an economic one when, in 1830, the material was mined for exportation and 8,348 tons were shipped in that year. Investigation has shown that this deposit extends for some 450 miles north and south in the arid plains which lie between the western slope of the Andes Mountains and the coastal range on the Pacific, at altitudes of from 3,600 to 13,000 feet and at distances of from 15 to 93 miles from the sea. The exploitation of this deposit has been pushed to such an extent that in the year ending December 31, 1908, there were shipped from the various South American ports contiguous to this field 1,993,000 tons of the nitrate of soda, and because of the export taxes levied upon this material and the payments required for concessions to operate in this desert tract, this industry has been and still is a rich source of revenue to the Chilean Government. The extent to which this industry has grown and its rate of growth are clearly set forth in the following table prepared by F. V. Vergara,[4] collector of customs at the port of Valparaiso:

Table 5.—Sodium Nitrate Exported from Chile, 1840–1903.

Period.	Exports.	Annual average.
	Tons.[1]	*Tons.*[1]
1840-1844	73,232	14,646
1845-1849	94,806	18,961
1850-1854	149,960	29,922
1855-1859	259,394	51,879
1860-1864	327,034	65,407
1865-1869	487,324	97,465
1870-1874	1,095,628	219,125
1875-1879	1,365,418	273,083
1880-1884	2,220,926	444,185
1885-1889	3,318,520	663,704
1890-1894	4,813,670	962,734
1895-1899	6,204,636	1,240,927
1900-1903	5,537,396	1,384,349

[1] Metric tons of 2,204 pounds.

This material was not only cheap and relatively abundant, but, as previously shown,[5] the richest known source of oxygen for use in explosives. It is not surprising, therefore, that its use for this purpose has rapidly grown. Nitrate of soda was first used in blasting powder in 1856, and a patent for such a powder was issued to La Motte Dupont in 1857. During the census year 1905 there was produced in the United States 205,436,200 pounds of blasting powder, most of which was nitrate of soda powder, and large quantities of this powder were manufactured and consumed in Chile and other countries.

As nitrate of soda is quite deliquescent it is not suitable for direct use in the compounding of gunpowder, but early after becoming available in commerce it was made a source of manufacture of saltpeter. It was during the Crimean war (1854–55) that this industry was established in Germany, the sodium nitrate being converted into potassium nitrate by means of potassium carbonate obtained from the residues of sugar beets, and this assisted in the promotion of the beet-root sugar industry which Germany was seeking to foster.

Singularly, about this time the now famous deposit

* Reprinted from United States Naval Institute Proceedings, vol. 35, No. 3. Copyright, 1909, by Philip R. Alger, secretary and treasurer, United States Naval Institute.

[1] Traité sur la poudre, les corps explosifs et la pyrotechnie, vol. 1, pp. 15-117, 1878.

[2] The Manufacture of Explosives, O. Guttmann, vol. 1, p. 24, 1895.
[3] Principles and Practice of Agricultural Analysis, H. W. Wiley, vol. 1, p. 16, 1894.
[4] *Monthly Bulletin International Bureau of American Republics*, November, 1903, p. 1290.
[5] Lectures on Chemistry and Explosives, p. 2, 1888, by Charles E. Munroe.

of potassium salts was discovered at Stassfurt, Germany. This town was noted for its salt works in the beginning of the nineteenth century, the source of supply being the natural brine from driven salt wells. With the utilization of rock-salt deposits in various localities, the price of salt was reduced to such a point that the Stassfurt works ceased to yield their former large revenue to the Prussian Government, and, with a view of making them again valuable, the Government began boring for rock salt in this locality in 1839. In 1857 a shaft, which began in 1852, reached, at a depth of 1,080 feet, a stratum of rock salt, but in doing so it passed through a heavy deposit of so-called "Abraum-salze" or refuse salts, which were then considered worthless. The "Abraum-salze" were found to consist largely of the minerals carnallite, which is a magnesium-potassium chloride; sylvite, which is potassium chloride; and kainite, which is a mixture of carnallite and magnesium chloride, and these refuse salts are to-day the chief source of the world's supply of potashes and potassium salts. Numerous uses have been found for them, not the least interesting of which is the production of saltpeter from the metathesis of the Chile nitrate with the Stassfurt sylvite or carnallite. In the United States alone there were produced 14,468,000 pounds of potassium nitrate by this means during the census year 1905, and this operation has been conducted here for many years. It is by such means that the Chile deposits have been made to render the saltpeter essential for use in sporting and military powders.

It has already been shown that the manufacture of dynamite consumes large quantities of nitrate of soda, and it has been also shown that the modern explosives, pyroxylin, guncotton, picric acid, and nitroglycerol, require for their manufacture a larger quantity of sodium nitrate, or of any other nitrate, as a source of the required nitrogen, than gunpowder does, while mercuric fulminate requires nearly as much. It may, therefore, be safely asserted that but for the discovery and exploitation of the nitrate fields of Chile the explosives industry, as it is known to-day, would have been impossible, and the developments in mining and transportation which have characterized the last half century could not have been made. That is, the condition of civilization amid which we now live could not have been attained.

Yet the explosives industry is but one of several in which nitrate of soda is used. The relative quantities used in various countries differ. Unfortunately no detailed and accurate statistics can be had except for the United States. Omitting the minor industries of enameling, fluxing in metallurgy, pickling of meats and fish, and the manufacture of subordinate chemicals in which approximately 23,926 short tons were used during the census year 1900, and 67,937 short tons in 1905, the quantities consumed in various industries were as follows:[6]

Table 6.—Nitrate of Soda Consumed in the United States by Establishments Classed as Follows.

Class.	1900.	1905.
	Short tons.	*Short tons.*
Fertilizer industry	19,518	42,213
Dyestuffs industry	223	261
General chemicals industry	35,990	38,048
Glass industry	10,770	11,915
Explosives industry	88,524	133,034
Sulphuric, nitric, and mixed acids industry	27,406	29,301
Total	182,431	254,772

It thus appears that of the total available supply of nitrate of soda in the United States but 42.90 per cent was used at the census of 1900, and 41.22 per cent at the census of 1905, in explosives factories, and of this a notable portion was used in the manufacture of saltpeter which was sold for other uses in the arts. While all the industries enumerated show a growing demand, the largest increase in any single industry is found in the fertilizer industry, where 22,695 tons, or 116.2 per cent more of nitrate were used at the census of 1905 than were used at that of 1900.

While no detailed statement of the consumption of nitrate of soda elsewhere is available, there is issued semi-annually by W. Montgomery & Company (Limited), of 63 Mark Lane, London, a statement of the total shipments, consumption, stocks, and prices of this article during a considerable period, and the following data are derived from their circular statement for December 31st, 1908:

Table 7.—Consumption of Nitrate of Soda in 1908.[1]

Locality.	Tons.
United Kingdom	104,000
Continent of Europe	1,272,000
United States	309,000
Other countries	45,000
Total	1,730,000

[1] The circular of Montgomery & Co. for June 30, 1910, gives the revised figures for 1908 as follows: United Kingdom, 99,000; Continent of Europe, 1,233,000; United States, 315,000; other countries, 55,000; total, 1,702,000 tons. From these data the percentage of the total consumption for the United States is 18.51.

[6] *Journal of Industrial and Chemical Engineering*, I, 298, 1909, by Charles E. Munroe.

Table 4.—Per Cent of Nitrogen in Certain of the More Important Explosives.

Explosive.	Acid components of nitrating mixture. (1) H_2SO_4	Acid components of nitrating mixture. (2) HNO_3	(3) Weight of acid per 100 of raw material.	(4)[1] Weight of product per 100 of raw material.	(5) Per cent of contained nitrogen.	(6) Equivalent of HNO_3 in 100 parts of product.	(7) Equivalent of $NaNO_3$ in 100 parts of product.
Blasting powder				100	12.20	54.85	74.00
Gunpowder				100	10.40	46.74	63.00
Guncotton	78.6	21.0	1,200.0	150	13.40	60.30	81.34
Mercuric fulminate	65.0	35.0	1,200.0	120	9.85	44.33	59.79
Nitroglycerol	61.5	34.5	[2]689.7	[3]228	18.50	83.25	112.30
Picric acid	26.6	55.8	400.0 ([4]1,900.0)	220	18.30	82.35	111.08
Pyroxylin for S. P.	56.0	29.0	([5]5,000.0)	145	12.50	56.25	75.88

[1] Factory yields.
[2] Using artificial refrigeration, vide Census Bulletin No. 92 of 1905.
[3] Nitrating in pots.
[4] Nitrating in centrifugals.

From this it appears that of the total consumption of the year but 17.8 per cent was consumed in the United States. Analyzing the statement for the previous eight years, it appears that of the total, that consumed in the United States was, in 1900, 12.6 per cent; 1901, 14.1 per cent; 1902, 16.9 per cent; 1903, 18.76 per cent; 1904, 19 per cent; 1905, 19.9 per cent; 1906, 21.7 per cent; 1907, 21.1 per cent; so that there was a steady increase in the proportion of the total consumed in the United States up to 1906, but that for the next two years there was a drop such that in 1908 our proportionate consumption was less than for any year since 1902.

It is commonly understood that a much larger percentage of the Chilean nitrate is used in agriculture in Europe than is used in this industry in the United States, and that the proportion is steadily increasing. This use of nitrogenous fertilizers is in conformity with the teaching of Baron von Liebig, whose views have become gradually disseminated among the farmers. A marked impetus was given to this use of the Chilean nitrate by the remarkable address made by Sir William Crookes before the British Association for the Advancement of Science in 1898, when, in dealing with the problem of meeting the rapidly increasing demand for food, he pointed out that while the average yield of wheat was but 12.7 bushels per acre it had been demonstrated that the yield could be increased to 20 bushels by the use of 1½ hundredweight of nitrate of soda on each acre annually.

This increasing use, however, tends to exhaust the supply. Crookes estimated that if the nitrate were used over the whole area under cultivation at the rate he proposed, the Chilean deposits would be exhausted in four years. Vergara estimated that at the rate that the nitrate had been mined and exported between 1840 and 1903, as shown in Table 5, the Chilean deposits would be exhausted by 1938. Albert Hale, however, in a more recent review of the situation,[7] points out that these estimates were based on the contents of the deposits then known in the province of Tarapaca, and the extent to which they could be profitably worked, and states that deposits of such magnitude have since been discovered in the provinces of Antofogasta and Atacama, and the processes of recovery of the nitrate from low-grade ore (caliche) have been so improved that, at a rate of consumption of 5,000,000 tons annually, which he expects will be the normal demand in a few years, there is enough nitrate in these deposits to last three hundred years.

This is a more encouraging outlook, but, nevertheless, from what has been said it is evident that the world has for long been largely dependent on these Chilean deposits for the greater part of its supply of nitrate and the substances derived from it. In time of prolonged war, in case nitrate has become contraband, most countries have been obliged to resort to the vicious policy of niter farming, or, as our Navy Department has done since 1863, have accumulated in advance considerable stores of niter, and this condition would have continued to hold but for important advances recently made in the production of nitrate from atmospheric nitrogen, and through other developments in chemistry.

We have in our atmosphere an abundant supply of this element. It is estimated that the air over each acre of ground contains 33,880 gross tons of nitrogen. It is, however, free, and to be available for use it must be combined. The methods for effecting the fixation of this nitrogen have proceeded along three lines: (1) The production of nitric acid and nitrates; (2) the production of cyanides; and (3) the production of amids, and the first and last have now been brought to commercial success.

As early as 1755 Priestly had noted that nitrogen compounds were formed when electric sparks were passed through air, and not long after Cavendish produced saltpeter by absorbing air, so treated, in caustic potash solution. Repeated attempts have been made since high potential currents have become readily available to utilize this method and an establishment was erected at Niagara Falls, by the Atmospheric Products Company, to operate the Bradley and Lovejoy process.

[7] *Bull. International Bureau of American Republics*, p. 27, July, 1908.

This method, for which a United States patent was granted September 30th, 1902, consisted in producing in the air a flaming electric arc of minimum volume by the rapid rotation of electrodes carrying high tension currents, but while it yielded nitric acid the method proved too costly.

A more successful device was shortly after put into operation by Birkeland and Eyde[8] at Nottoden, Norway, and it has been in operation ever since. In this the flaming arcs produced by high tension currents were made to move to and fro through the air within the apparatus by exposure to powerful magnets. This apparatus was characterized by a narrow chamber through which the air was passed and within which the electrodes, placed near together, were arranged between the poles of a strong magnet and at right angles to these poles. A disk-shaped or deflected electric arc was thus obtained perpendicular to the lines of force of the magnetic field. Three such furnaces at Nottoden, using 500 kilowatts and 5,000 volts, gave deflected arcs about 3 feet in diameter. The nitrogen oxides formed were quite dilute and they were carried to absorption towers where, by contact with milk of lime, calcium nitrate was formed, the product being eventually converted into basic calcium nitrate for use as a fertilizer. According to O. N. Witt,[9] with this apparatus an output of 500 to 600 kilos of nitric acid per kilowatt year can be regularly maintained.

A still more efficient form of furnace is that devised by Dr. Otto Schoenherr for the Badische Anilin and Soda Fabrik. From his lecture, delivered June 11th, 1908, before the Verein Deutscher Chemiker at Jena, it appears that what is sought in these processes is to burn the nitrogen with the oxygen of the air. To accomplish this to any satisfactory degree the gases must be exposed to a temperature of 3,000 deg. C. (5,432 deg.F.) and[a] upward. To prevent the decomposition of the product formed it must be immediately removed to a cooler region. This Birkeland and Eyde accomplish through moving the arc to and fro by the aid of magnets, while Shoenherr effects it by imparting to his air a gyratory motion about his elongated arc. His apparatus consists of a long iron tube in which an arc 5 meters (16.4 feet) in length, produced by an alternating current, is maintained constantly, the energy required being about 600 horse-power and the alternations being 50 per second. Air, which has been heated to 500 deg. C. (932 deg. F.) by the hot discharge of gases, is blown tangentially into this tube so that it surrounds the arc spirally in its passage through the tube. This prevents the deflection of the arc, permits of the maximum exposure of the air to the heat from the arc, and promptly sweeps the heated and reacting air to the cooler portion of the tube and beyond. A 2,000 horse-power plant of this character has been in operation at Christiansand, Norway, since the autumn of 1907, and its success has been such that the building of a 120,000 horse-power plant of this character has been undertaken at Rukwan Falls, Norway. The advantage claimed for this process is that it gives a good yield of concentrated gas.

The third method for the fixation of atmospheric nitrogen referred to above has been brought to a successful realization by Frank and Caro in their production of calcium cyanamid mixed with carbon or "lime nitrogen," or "nitrolim," as it is more recently called. This is produced[10] by heating calcium carbide in vertical iron retorts in an atmosphere of nitrogen, when the calcium cyanamid, mixed with carbon, is formed according to the following equation:

$$CaC_2 + N_2 \rightarrow CaCN_2 + C.$$

The nitrogen is obtained by liquefying the air and separating its constituents by fractional distillation, or by passing the air over heated copper, by which the oxygen is removed from it and the nitrogen separated. A plant with a capacity of nearly 4,000 tons per year was started at Piano d' Orta, Italy, in 1906, and with such success that the production was carried in 1908

[8] The Electrochemical Problem of the Fixation of Nitrogen, Phillippe A. Guye, *J. Soc. Chem. Ind.*, 25, 567, 1906.
[9] *Chemiker Industrie*, 28, 699, 1905.
[10] Report on Calcium Cyanamid, Charles E. Munroe, Washington, April 27, 1907.
[11] Bulletin No. 65, Census of Manufactures, 1905, Coke, p. 18, by Charles E. Munroe.

to over 40,000 tons per annum in five plants, with others building. The material as produced is used directly as a fertilizer, but it is a simple matter to obtain ammonia from it and by a contact process this may be directly converted into nitric acid.

Yet another indirect source of supply of nitric acid and, therefore, of saltpeter is found in the manufacture of coke, for an important product of the by-product coke industry is ammonia, which is obtained usually nowadays as ammonium sulphate. I have elsewhere shown[11] that 15,773 tons of ammonium sulphate were produced in this country in 1905. But as only 3,317,585 tons of the 37,376,251 tons of coal coked in the census year were coked in by-product ovens it was possible, had all been so treated, to have obtained 359,560 tons of ammonium sulphate, all of which if desired could have been converted into nitric acid for use in the manufacture of saltpeter or of any desired variety of explosive.

From this account of recent chemical progress it is evident that it is possible to conduct a prolonged war without robbing the soil on which the people depend for food of its fertility, and further, that, notwithstanding the enormous and constantly increasing demand for nitrogen compounds in agriculture and manufacture, this country has reached a potential degree of independence, as regards its supply of nitrogen compounds for military uses, such as it never before enjoyed, so that it needs hereafter to consider foreign sources of supply only from the economic standpoint. However, I desire to say regarding the plants for the fixation of nitrogen what I have repeatedly advised regarding plants for the manufacture of explosives, viz., that it is a wise policy for our Government to foster, and in a measure supervise, these manufacturing operations, and to look to it that plants for these purposes are so strategetically located throughout the country as to be reasonably well protected from attack, so that they may serve the military establishment in case of foreign invasion from any quarter or of internal uprisings in any locality.

On the Proper Motions of the Fixed Stars*

By W. DOBERECK, Ph.D., F.R.A.S., M.R.I.A.

HALLEY found that some of the brightest fixed stars had changed their places since they had been observed by the ancient Greeks, and such changes are so obvious as to be recognized on ancient coins. Sir William Herschel, in 1783, arrived at the conclusion that a relative motion of the sun among the fixed stars in the direction of a point situated near λ Herculis would account for the greater part of these proper motions: the motion of the sun towards the "apex" must cause the fixed stars in half the sky to apparently move away from that point, and in the other half of the sky to move towards the diametrically opposite point, the "anti-apex." Since then a great many astronomers have determined the situation of the "apex," but the results do not agree very well, especially as regards the declination. Bessel investigated the matter and declared himself dissatisfied with the evidence. When the direction of the proper motion of a fixed star has been ascertained, a great circle laid through the positions of the star observed at two epochs is thereby determined, and if the great circles belonging to different stars intersect in a point (the apex), it is easy to see that the poles of these great circles must lie on another great circle, of which the apex is the pole. Bessel found that the poles do not lie on or near a great circle, but are scattered over the sky. Kobold, the editor of the *Astronomische Nachrichten*, who some years ago took up Bessel's investigations, proceeds as follows. He imagines the celestial sphere inscribed in a cube which touches the sphere at the two poles and at four points on the Equator. He supposes the eye of the observer situated in the center of the sphere, and any great circle on the sphere is then projected as a straight line on one or more of the faces of the cube. Kobold had already used maps made on this principle in determining radiants of shooting stars, and the writer had subsequently, in Hongkong, used similar maps for the same purpose. Kobold projected the poles of a great number of proper motions in such maps. Those that correspond to proper motions intersecting in the apex should lie on a straight line corresponding to the great circle of which the apex is the pole, but that is not clearly shown on the maps.

Kapteyn, who has the merit of having originated many hypotheses that appear destined to aid greatly in the astronomy of fixed stars, solves the difficulty by accounting for a great number of proper motions on the supposition that there are two distinct apices both close to the galaxy. It had, indeed, in course of years, become the general impression that the galaxy is made up not of isolated heavenly bodies, but of a conglomerate of clusters of stars and nebulæ. There was, therefore, nothing extraordinary in the circumstance that the stars belonging to two clusters did not move in the same direction. Kapteyn's hypothesis has been examined at the Greenwich Observatory and confirmed there by the independent evidence of proper motions, other than those used by Kepteyn. It has been confirmed also at the Cape of Good Hope. It has been to some extent confirmed by spectroscopic evidence at the Cape Observatory and at the Lick Observatory.

The speed in miles with which a star is moving towards or away from the earth can be measured in the spectrum, the wave-length of the lines being respectively shortened or lengthened, and it is found that the stars on opposite sides of the sky indicate a general drift, or even two drifts; but the objects used should be evenly distributed over the whole sky, and the spectra of only a few faint stars are known with sufficient accuracy for this purpose.

Meantime other radiants have been found. Boss, editor of the *Astronomical Journal*, has shown that the Hyades form a greater cluster moving in parallel lines towards a certain radiant point. Another apparently (but perhaps only apparently) much larger cluster, which has been investigated at the Potsdam Observatory, contains the stars in the Great Bear, Sirius, and other bright stars.

As mentioned above, the spectroscope enables astronomers to measure the motion of a heavenly body in the line of sight in miles per hour. The proper motion, expressed in seconds of arc, shows how much it is moving in the line perpendicular to the line of sight. When the direction of motion in space is known, then the parallax is at once obtained from these two quantities, and that direction is given by the radiant. Parallaxes of fixed stars are more accurately determined in this way than by any other method. Numerous results have been obtained. They show that the magnitude of a star forms no guide to its distance from us. Stars of different intrinsic brightness are mixed in space. Therefore, it would be no wonder if some of the small telescopic stars should turn out to be compartively near the Solar System. Proper motions have hitherto been determined by comparing positions recently determined by the meridian circle with older results. Burnham, at the Yerkes Observatory, has of late years determined a number of proper motions by aid of micrometric measures compared with previous measures made by Struve, Sir Robert Ball, and others. In those cases where his results differ from the result of meridian work, the difference is probably caused by hitherto unsuspected proper motions of faint stars, which it will be possible to determine by future micrometric measures compared with Burnham's observations. At Heidelberg proper motions of faint stars are discovered by simply looking in a stereoscope at photographic plates of the same part of the sky taken several years apart. Turner has discovered large proper motions of stars as faint as the eleventh magnitude marked on photographic plates, and states that stars with proper motions greater than fifteen seconds per century are scattered with no sensible reference to the galaxy.

It may be asked what becomes of Herschel's explanation of the apex caused by the sun's proper motion when there are not one but many apices. It should be kept in mind that all motion is relative, and it is quite legitimate to attribute the apex of the cluster that contains the largest number of stars to the proper motion of the sun. Boss has lately discussed about six thousand proper motions, and he determines the apex without taking into account the existence of different systems, and also without excluding any objects.

It appears that all the radiants so far found lie near the galaxy, and it is much easier to determine additional radiants on the supposition that they all lie near the galaxy, than if they were scattered over the sky. If the pole of the galaxy is projected on Kobold's maps, and also the straight line (or rather lines) corresponding to the great circle of the galaxy, any straight lines from the projected pole to any point on the projected galaxy represents a great circle perpendicular upon the galaxy, and the projected poles of proper motions that lie near this line indicate stars the radiant of whose proper motions is the pole of the galactic meridian in question. By investigating the proper motions all round the sky in this manner it should be easy to discover all the radiants that lie near the galaxy.

Kapteyn, on the supposition that there are only two radiants, explains these as being caused by stars moving in two diametrically opposite directions, and the fact that they do not appear to be diametrically opposite he explains by combining the proper motion of the sun with each of them. In this way the direction of the sun's proper motion is determined, but it is seen that the sun belongs to neither of the clusters. However, there are probably more than two star streams, and there is so far no reason to suppose that they move in exactly opposite directions.

It is conceivable that two globular clusters might attract each other, approach, and pass through to the opposite side. When they had reached the same distance apart on the other side they would stop, and their motion would be reversed. The period of the swing of such a pendulum would exceed millions of years. But when the enormous distances between the stars are taken into account, and their relatively insignificant masses, the forces are found too insignificant to account for existing proper motions. The energy of runaway stars cannot be derived from attractions between fixed stars or clusters: it may be due to explosions.

As all observations of heavenly bodies are made by comparison with positions of fixed stars, the accurate determination of the proper motions of the latter may be said to be in some sense the most important object of astronomical observation. Several astronomers, especially Porter in Cincinnati, have devoted their energies to the discovery and determination of proper motions. An international co-operation between observatories in all parts of the world is being arranged to make a determination with the utmost accuracy of the positions of a very great number of fixed stars evenly distributed over the sky to serve as standards for determining the positions of faint stars recorded on photographic plates. But however perfectly the catalogue embodying the results of such co-operation may reflect the actual situation in the sky of the stars it contains, it must in a few years become quite inaccurate as the stars change their places, and for the determination of these changes the catalogue must rely on observations made in the past, so that the old observations, far from being superseded, gain in importance; and the older they are, the more important it becomes to take them into consideration.

* From *Knowledge*.

Plate for Indexing in Degrees.

AT one time it became necessary to affix an indexing plate to a machine so as to be able to set a pointer at any one of the 360 degrees of a circle. The ratchet *A* was not large enough to allow cutting 360 teeth in it, as these teeth had to withstand a moderate straining due to a flat coiled spring not shown in the illustration. Accordingly 120 divisions were provided

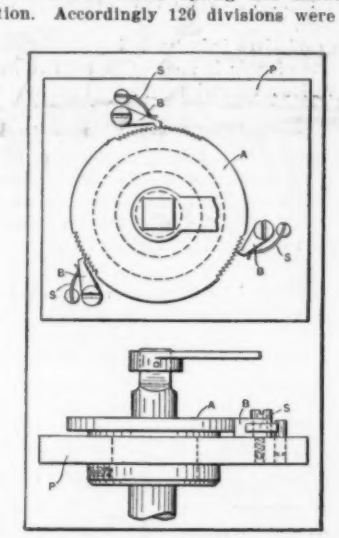


Plate which, by the Aid of Pawls of Unequal Lengths, Indexes to Degrees.

in the ratchet and the pawls *B* were made so that they differed in length by 1/3 the distance between two of the ratchet teeth, or in other words by 1/3 the pitch of the teeth. The action of the pawls is, therefore, consecutive; No. 1 first engages the ratchet, then if the pointer is moved 1/360 of a revolution, or one degree, No. 2 engages and so on. The pawls are kept in engagement with the ratchet by means of the flat steel springs *S*, as shown. The whole fixture is supported on the plate *P*, which is part of the machine.—*Machinery*.

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